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An elementary
laboratory course in
psychology

AN ELEMENTARY LABORATORY COURSE IN PSYCHOLOGY

BY

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INTRODUCTION

It has been our aim in preparing this manual to describe the experiments in such a manner that students who have had only an introductory course in psychology may be able to perform them without further assistance. With this in mind we have tried to give full and minute descriptions even to the point of explaining what may seem obvious to many. We have also given exact directions in regard to the recording of results, even to the extent of supplying models for the tables when necessary, for we consider that training in the systematic arrangement of results is one of the purposes of an experimental course.

The selection of the experiments has been conditioned by the following practical and theoretical requirements: —

1. It should be possible to perform all the experiments in a half-course of five hours a week.
2. It should be possible to perform the experiments with very simple and inexpensive instruments. In most instances when complicated instruments have been employed an alternate experiment with simple apparatus has been described. Two or three experiments, owing to their importance, have been included which demand special instruments. These experiments have been starred.
3. It is necessary in most institutions that the experiments be performed by the entire class in one room. It is obvious, therefore, that some experiments in audition, vision, etc., had to be omitted.
4. The experiments should not be too difficult for students beginning psychology. In fact it is hoped that the book may prove useful not only for class work, but for private students who desire an introductory knowledge of experimental psychology.

5. The experiments should present the most essential features in method and the important facts of psychology.
6. It should be possible to obtain clean-cut results and they should be capable of treatment by the student.
7. The experiments should not be too fatiguing as would be a complete verification of Weber's Law, nor disagreeable as are many of the taste and smell experiments.

In order to meet these conditions, compromises had to be made, and for one reason or another some experiments have been omitted which appear in standard textbooks. On the other hand, new experiments, arranged to cover what seemed to us important facts, have been included.

Questions have been appended to each experiment. These have been carefully arranged to direct the student's attention to the main purpose of the experiment, to the reasons for the various stages in the method, to the connection between the results of the various experiments, to the facts and theories, both physiological and psychological, connected with the experiment, and to the practical application of the results. The difficult questions have been starred and may be omitted if deemed advisable.

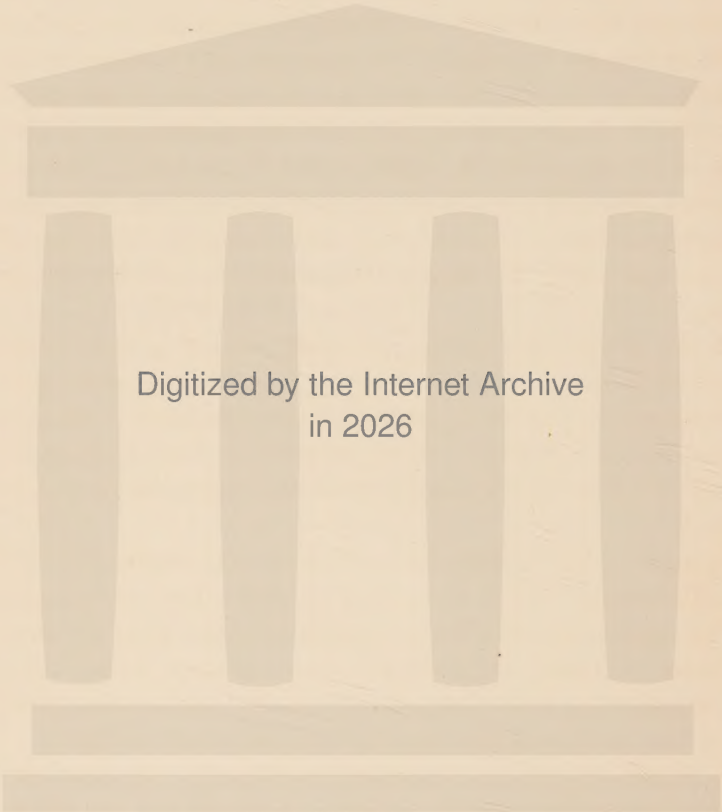
Most of the experiments are to be performed by the students working in pairs. One student acts as subject, the other as experimenter. A few experiments, entitled "Individual Experiment" are performed by each student upon himself. Some important experiments, however, could not be arranged to be performed by each pair of students separately. These are entitled "Class Experiment." In these the instructor or one of the students acts as experimenter and the class as a whole acts as subjects.

It is advisable to tabulate as far as possible the results of all the members of the class for a comparison of the individual records, and also to obtain averages for large groups. Directions for doing this have been given in a number of experiments. If the class is very large, however, this must be omitted, unless the class can be divided into small sections.

We must acknowledge our indebtedness to Professor E. B. Titchener's *Experimental Psychology*. As the influence of this book is felt in every corner of the psychological laboratory of to-day, an attempt to make specific acknowledgments to him would, we fear, involve grave omissions. We have also profited from *An Experimental Study of Sensation*, by Professors E. B. Holt and R. M. Yerkes. We used this book at Harvard for a number of years and have received numerous suggestions from it. One of the experiments on "Attention" was devised by Professor Münsterberg, and we have to thank him for his permission to use it as well as for his valuable advice. We also wish to thank Professor E. B. Holt for his aid in several important decisions, and Professor W. F. Dearborn for suggestions regarding some of the problems of perception.

HERBERT SIDNEY LANGFELD
FLOYD HENRY ALLPORT

CAMBRIDGE, MASS., *October, 1916.*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FOREWORD TO THE STUDENT

At the beginning of the course you are to select a congenial partner with whom to work. It is advisable that this partnership remain unchanged throughout the semester. One member of the pair acts as subject and the other as experimenter. These positions must be reversed in the successive experiments, the subject in one experiment being the experimenter in the next. Some experiments, however, are repeated so that each member shall have the experience both of experimenter and of subject. The work is done at small tables, the subject being seated opposite the experimenter.

It is the aim of experimental psychology, as it is of every other science, to be exact. You are therefore to take the greatest care in the arrangement of the experiment, so that the mind of the subject can be studied under known conditions. The observations must also be most conscientiously made and the results accurately recorded.

You must realize the importance of these requirements from the start. Remember that it is an ideal of science that experiments shall be capable of repetition at some future time under the same conditions. If these conditions are not accurately known, there is small possibility of verifying the results, and without such verification the results will have very little if any scientific value.

The experimenter is able to control and describe the outer conditions of the experiment; the subject must control and describe as far as possible his own states of mind. This observation of his mental states is known as 'introspection,' and in all the experiments the subject is called on to report upon these states. The records must contain both the so-called 'subjective' and 'objective' conditions and results, of the experiment.

Provide yourself with a notebook containing detachable sheets of cross-section paper divided into one half centimeter squares. Write only on one side. It is suggested that the experiments be arranged in the notebook in the following manner: —

EXPERIMENT I

SENSATION

I. Vision

1. The Blind Spot

Date:.....Subject:.....

Experimenter:.....

Materials:.....

.....

.....

.....

Method:.....

.....

.....

.....

.....

.....

.....

Record:.....

.....

.....

.....

.....

.....

.....

.....

.....

Questions:

1.....

2.....

etc.

Place the questions on a separate sheet. The method of the experiment should be described in your own language and with such completeness that any one reading your notebook would know how the experiment had been performed. Any peculiar conditions of the experiment, such as a headache of the subject, should be noted. The subject will have to obtain the records for his notebook from the experimenter.

Before starting an experiment, always read the entire description including the questions.

In order the better to understand the methods and results, as well as to obtain knowledge of further experiments, the following books are suggested: E. B. Titchener's *Experimental Psychology*, G. M. Whipple's *Manual of Mental and Physical Tests*, C. E. Seashore's *Elementary Experiments in Psychology*, and E. C. Sanford's *A Course in Experimental Psychology*.

Answer the questions fully, giving them careful thought. You will be well repaid for the time spent upon them by the better insight you will obtain into the purpose and implications of the experiment. The following books will aid you in answering the questions: For the physiological facts, C. J. Herrick's *An Introduction to Neurology*, K. Dunlap's *An Outline of Psychobiology*, E. A. Schaefer's *A Textbook of Physiology*, W. H. Howell's *Textbook of Physiology;* for the facts and theories of psychology, G. T. Ladd and R. S. Woodworth's *Elements of Physiological Psychology*, C. S. Myers's *A Textbook of Experimental Psychology*, E. B. Titchener's *A Textbook of Psychology*, H. Münsterberg's *Psychology, General and Applied*, and J. R. Angell's *Psychology*.

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MATERIAL AND INSTRUMENTS

REQUIRED

FOR EACH PAIR OF STUDENTS

Ruler with inch and millimeter scale
Small fine-pointed scissors
Paste
Yardstick
Very soft pencil
Colored paper including white, black, and gray
Black, white, and gray cardboard
Small dividers
Milton-Bradley color tops and discs
Pasteboard mailing-tubes
Black burrs no. 3 (washers)
Wooden skewers
Metal rods
Small bottles of
  Tincture of iodine
  Spirits of camphor
  Nitro-benzole
  Oil of camphor
  Eau de cologne
  Oil of turpentine
  Oil of lavender
  Oil of bergamot
  Oil of cloves
Boar bristles
Sealing wax
Tumblers
Needle
Tissue paper

FOR THE CLASS

Measuring tape
Stop watch
Two tuning-forks of equal pitch such as C^2 or A^1
Rubber hammer
Beeswax
Color wheel
Color discs (large)
Rubber stamp and pad
Balance or letter scale
Metronome
Piece of felt
Set of gummed digits

OPTIONAL

Chronoscope
Telegraph keys
Sound keys
Batteries
Langfeld-Dearborn Tachistoscopes
Perimeters
Pianoforte or organ or set of tuning-forks
Two hammers with rubber tips
Color wheels
Color discs and measuring discs (large)
Stereoscopes
Sound cage
Two telephone receivers
Rheostat

The material can be obtained from C. H. Stoelting Co., 3037–3047 Carroll Ave., Chicago, Ill.

AN ELEMENTARY LABORATORY COURSE IN PSYCHOLOGY

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SENSATION

I. VISION

1. The Blind Spot (1[1])

(*Individual experiment* [2])

Materials: Ruler. Four white cards, $4\frac{1}{2}$ x 10 inches, to be prepared as in figure 1.

The diameter of the colored disc at the right is one inch. The distance between the black dot and the center of the disc is in each card 5 inches. The colored backgrounds in (2) and (3) are $3\frac{1}{2}$ inches square.

Method: This experiment is to be performed separately by each of the students. Hold card no. 1 so that the black dot is in front

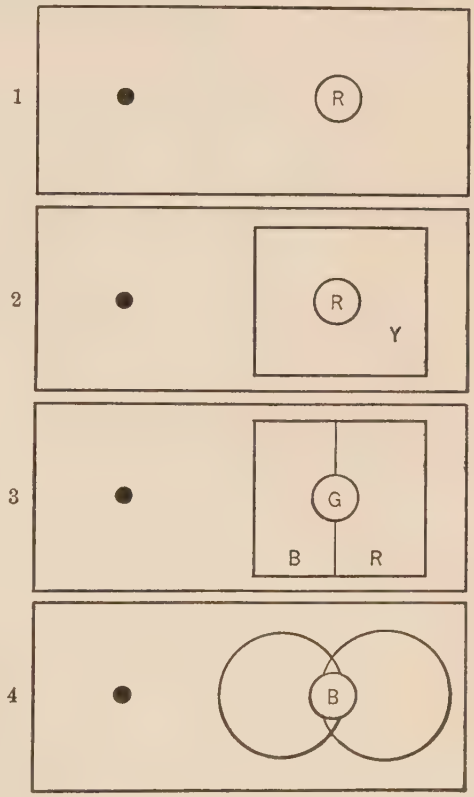


FIG. 1.

The colors red, yellow, green and blue are to be used as indicated by letters in the figures.

[1] Each experiment contains a number in this position which indicates the serial number of the experiment.

[2] To be performed by each student upon himself.

of the left eye and the colored disc in front of the right. Close the left eye and fixate the black dot with the right. Move the card toward you and away from you, still keeping the right eye fixated on the black dot, until the colored disc disappears. Note the appearance of the background after the disc has disappeared. Repeat, using each of the other cards.

Record: (1) For card no. 1: State the approximate distance from the eye at which the disc disappears.

(2) For cards nos. 2, 3, and 4: Present drawings and descriptions indicating the appearance of the background with special reference to that part from which the disc has disappeared.

(3) For card no. 2: Describe any change in size which may occur in the yellow background.

(4) State whether the disc can be made to disappear only at a certain point, or whether it remains blotted out during a certain movement of the card toward you and away from you. If the latter, record the extent of this movement in inches.

Be careful to keep the eye fixated on the black dot.

Questions: 1. Describe a method suggested by the results of this experiment for ascertaining the size of the blind spot.

2. Explain a possible method for mapping out the shape of the blind spot.

3. Give at least two reasons why we are not conscious of the blind spot in reading.

2. Retinal Induction (Simultaneous Contrast) (2)

(*Individual experiment*)

Materials: Two one-inch squares of the same medium gray paper. Three-inch squares of black, white, red, green, blue, and yellow paper. A six-inch square of white tissue paper.

Method: A. Brightness Induction. — Place the black and the white squares side by side, and on each, one of the gray squares. Cover these with the tissue paper. Note the change in the relative brightness of the two grays.

B. Color Induction. — Place a gray square on the red square and cover with tissue. Note the change which occurs in the gray square. Repeat, using the other colors.

Record: Write a description of the changes which occurred in the gray under the different conditions.

Questions: 1. Give a physiological explanation of retinal induction.

2. How may the phenomenon of retinal induction be made to serve æsthetic purposes?

3. Describe instances of retinal induction which have occurred in your observation of nature.

3. Negative After Images (3)

Materials: Three pieces of cardboard six inches square: — black, white, and medium gray. A two-inch square of black paper. One-inch squares of the following colors: — white, red, green, blue, yellow, and violet.

Method: The experimenter places the square of black paper on the gray card and the square of white paper on the black paper. The subject fixates the middle of the white square for fifteen seconds. The black and white paper squares are then quickly removed while the subject holds his fixation point constant. He notes the quality of the resulting after image. The after image may not appear at once; the subject should continue to fixate until it appears. With a slight amount of practice it will be readily observed.

Repeat this procedure, using the black and white cards in turn as backgrounds.

Now proceed as before with the red square, placing it in turn on each of the three backgrounds. Treat each of the other colors in the same manner. The large black square of paper is not used in connection with the colors. The subject observes the changes in hue. He notes also the differences in brightness and saturation (amount of color) of the after images on the three backgrounds, expressing the degrees of brightness and saturation separately on an arbitrary scale of one (least) to three (greatest). Temporal aspects such as duration and intermittent appearance of the after image are also to be observed.

Record: (1) For black and white. (*a*) Give a comparison of the after image obtained in the first procedure, with the original paper squares. (*b*) Compare also the three after images on the three different backgrounds in regard to differences of brightness. (*c*) Describe the effect of the movement of the eyes on the after image.

(2) For colors. The results should be tabulated as shown in the table.

Questions: 1. Was there a fringe of color or brightness about the paper squares? If so, describe and explain it.

COLOR	AFTER IMAGE			
	Aspects	White Background	Gray Background	Black Background
R	Hue	Blue - Green		
	Brightness	3		
	Saturation	1	etc.	
Y	Hue			
	Brightness			
	Saturation			
G	Hue			
	Brightness			
	Saturation			
B	Hue			
	Brightness			
	Saturation			
V	Hue			
	Brightness			
	Saturation			

2. Give reasons for the differences in the appearance of the after images which result from the use of backgrounds of different brightnesses.

3. Describe after images which you have observed in your everyday experience.

4. Why do we call this experiment a study of *negative* after images?

5. Are these after images of central or of peripheral origin? Upon what observation do you base your answer?

6. Give a physiological explanation of after images.

4. Retinal Color Fusion (Method of Positive After Image) (4)

Materials: Color-wheel.[1] Discs of red, green, blue, yellow, violet, and orange. Measuring disc graduated in degrees.

Method: (1) The experimenter places a blue and a yellow disc interlapped on the color-wheel. He regulates the amounts of each until on turning the wheel a smooth pure gray is obtained. The wheel must be revolved with sufficient rapidity to eliminate flicker. The subject indicates when the desired gray has been attained. Measure the amount of each color in degrees. Repeat, using red and green.

A pure gray will not result from the red and green. An addition of blue will, therefore, be needed.

Find the hues and their proportions which are necessary to add to violet and to orange respectively in order to produce gray.

(2) Determine the result of mixing blue and green, and of mixing blue and red.

Record: For 1. (*a*) Tabulate the proportions of colors necessary in each case to produce gray. (*b*) State the hues and their proportions which can be said to be "complementary" to orange and to violet respectively.

For 2. Name the hues resulting from the mixture of the colors given. [The pairs used in (2) are called "non-complementaries."]

Questions: 1. From the results of your experiment formulate the laws of retinal color fusion.

2. Why do the colors fuse when the wheel is revolved?

[1] The Milton-Bradley color tops and paper discs may be used instead of the color-wheel.

5. Retinal Color Fusion (Method of Negative After Image) (5)
(*Individual experiment*)

Materials: One-inch paper squares of red, green, blue, yellow, black, and white. Background of medium gray cardboard.

Method: (1) Place the red square on the gray background and fixate its center for fifteen seconds. Fixate immediately thereafter the upper right-hand corner of the red square. Note the changes which may occur in any part of the colored square, or in the background. Proceed in the same manner, using each of the other colors and also the black and white.

(2) Now fixate the red on the gray background for twenty seconds. Remove it quickly and place a blue square in its place, fixating the upper right-hand corner. Note the changes which occur in the blue square. Repeat, using a blue and then a green square in the same manner. Make one more trial, using a red and then a yellow.

Record: Sketch and describe what you see for each of the six after images in part 1, and in the three observations in part 2.

Questions: 1. Do the results of this experiment confirm the laws of color fusion you gave in the last experiment? If so, how?

2. Explain the difference in principle between this experiment and the preceding?

6. Relation of Brightness to Retinal Fusion (6)

Materials: Color-wheel.[1] Discs of black, white, red, green, blue, and yellow. Measuring disc.

Method: The experimenter places a black and a white disc interlapped on the color-wheel in such a way that 180° of each is exposed. Revolve the wheel at a rate that is just sufficient to eliminate all flicker. Count the number of revolutions of the handle of the instrument at this rate for ten seconds, and compute the average number per second. Repeat the experiment, using in turn the following pairs of colors: red-blue, green-blue, yellow-green, and yellow-red.

Record: Tabulate the rate required for fusion in the case of black and white, and for the different color pairs respectively.

Questions: 1. From your results what law can you formulate concerning the relation between brightness difference and the rate of revolution required for fusion?

2. It is difficult accurately to compare two colors in regard to brightness. This is owing to the difference in hue. Describe an indirect method of making such a comparison, using this experiment as a basis.

3. At a low rate of speed of the wheel you observed a rough flicker. Why was it necessary to increase the speed in order to produce a smooth surface?

*[2]4. Does the center of the wheel fuse at a slower rate than the periphery? If so, explain why.

[1] If only one color-wheel is available, this may be performed as a class experiment in which the instructor operates the instrument and the class judges when the flicker disappears.

[2] Especially difficult questions are starred, to be omitted at the discretion of the instructor.

7. Color Zones of the Retina (7)

Materials: Perimeter. Small squares of red, green, blue, and yellow paper.

Method: While making the judgments required in this experiment the subject rests his chin on the chin-rest of the perimeter, closes his left eye, and with the right fixates the white fixation point. The right eye is used throughout. With the perimeter arc in the horizontal position the experimenter places a square of red in the holder and starting at the extreme right end of the arc moves the holder gradually toward the center until the paper square is seen by the subject. Note down this point in degrees. Continue to move the holder toward the center until the paper is seen as red. Make a note of any color changes which occur before the red is seen. Note down the degree at which the color is first seen as red.

Next starting from the center move the holder outward toward the right until the red disappears — either turning to gray or appearing as some other color. Note the degree at which the red disappears. Continue moving outward and note the degree at which the paper itself disappears. At no time should the subject's eye leave the central fixation point.

Repeat the procedure, moving out and in on the left side of the perimeter arc.

Now adjust the arc in a vertical position and make corresponding measurements going in and out in the half above the fixation point, and the same in the half below the fixation point. Sixteen measurements will now have been obtained.

The same method is followed for each of the other colors, omitting however the measurement of the points at which the paper itself disappears, and noting only the degrees at which the color appears or disappears. For record, etc., see below.

Simplified method

Materials: A sheet of white cardboard approximately 14 x 24 inches. Colored paper squares as in the foregoing method. Ruler.

Method: Place the cardboard with the long edge horizontal to the subject. Draw two lines, one bisecting the card vertically, the other bisecting it horizontally, and place a dot at their intersection. The subject leans well over the paper resting his chin on his two fists, one of which is placed on top of the other. His left eye should be closed and his right eye directly over the black dot, which he fixates during the various trials.

The experimenter moves the colors severally in and out in the four directions indicated by the intersecting lines. That is, the colors are to be moved along the lines on the right, on the left, above, and below the fixation point respectively.

The procedure to be used was described under the foregoing method. Place small marks at the points where the subject reports the various changes in the colors. Rests are to be allowed to offset fatigue.

Record: (1) Tabulate the measurements according to the table given below. [It should be borne in mind that since the rays of light cross after entering the eye, a point to the right of the fixation point will fall on the left or nasal half of the retina of the right eye; and a

COLOR	NASAL			TEMPORAL			SUPERIOR			INFERIOR		
	IN	OUT	AVG.	IN	OUT	AVG.	IN	OUT	AVG.	IN	OUT	AVG.
RED												
YELLOW												
GREEN												
BLUE												
LIMIT OF VISUAL FIELD (PAPER DISAPPEARS)												

point to the left of the fixation point will fall on the right or temporal half. Similarly the lower part of the perimeter (or cardboard) will correspond to the superior half of the retina, and the upper part to the inferior half.] If the perimeter is used, the results will be recorded in degrees. If the simplified method is used the distances will be expressed as centimeters measured from the central dot.

(2) Express as centimeters the degrees of the *average* measurements in the four directions for each of the four colors and for the limits of the visual field. For example, ten degrees are represented graphically as ten centimeters. Lay out these numbers in a convenient scale on a map representing the horizontal and vertical axes. If the simplified method was used the results will be already in centimeters, but will probably require reduction to a convenient scale. Connect the points which you have laid out for the several colors by means of curves, as shown in figure 2. Indicate which color zone each curve circumscribes. It is possible that the curves you obtain may cross each other.

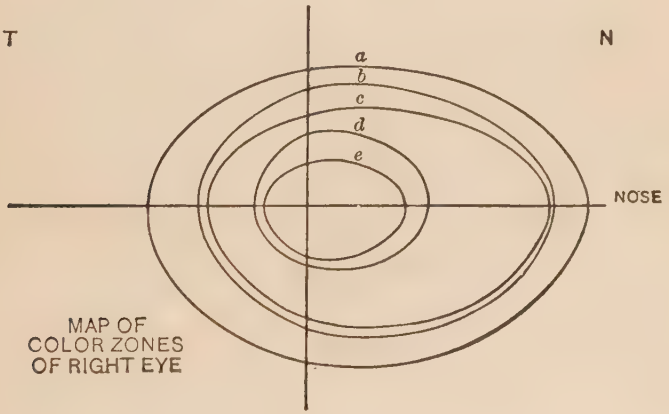


FIG. 2.

In the figure *a* represents the limit of the visual field; *b*, *c*, *d*, and *e* suggest the relations of the four color zones which are to be mapped out and named.

(3) Give an account of any hues that were observed (in bringing a stimulus toward the fixation point) between the point where it appeared as gray and the point where it took on its final hue.

Questions: *1. Was the change from gray to color, or vice versa, sudden or gradual? Formulate a physiological theory to explain your answer.

2. Moving in, at what point in your map would an orange square first be seen as orange?

3. If the subject in this experiment had the most common form of color blindness, how would the color map appear?

4. What point of similarity do you find between the results of this experiment and of those experiments involving positive and negative after images and color fusion?

5. Explain a method of determining the brightness of colors suggested by this experiment.

6. Why do you not usually observe this phenomenon in ordinary visual perception? Give two reasons.

8. Binocular Inhibition and Fusion (8)

Materials: Stereoscope.[1] Piece of cardboard cut to fit the holder of the stereoscope. Squares of red, green, blue, yellow, white, and black, cut one half the size of the cardboard so that one can be placed in each field of vision. Two pieces of white cardboard cut the same size as the paper squares, each bisected by a black stripe one quarter inch in width.

Method: Place the two striped cardboards in the stereoscope, one with the stripe horizontal, the other with the stripe vertical. The subject looks through the stereoscope and notes the changes which occur for one minute. The larger piece of cardboard may be used in this and the following steps for a supporting background.

Place the following pairs of colors in turn in the stereoscope, with a separate color for each eye: red-green, blue-yellow, red-yellow, black-white. The subject observes each pair for one minute.

Record: Present in tabular form a report of the occurrence of the following possible phenomena for each pair.

1. Number of times the image of the right eye was inhibited.

2. Number of times the image of the left eye was inhibited.

3. Approximate length of time both images were seen occupying the same space. Record accurately the different ways in which this combined image appeared. In the case of the black stripes note especially what is seen at the place where the stripes cross.

Questions: 1. From a survey of your results determine the following points:

(*a*) The bearing of the complementary relation of colors on the rate of alternation.

(*b*) The bearing of the brightness relation of colors on the rate of alternation.

[1] If stereoscopes are not available the phenomena of inhibition and fusion of colors may be observed by placing pieces of colored glass close to the eyes. Put one color (as indicated in the method) close in front of one eye, and the other color in front of the other eye.

2. Discover and state the effect of voluntary attention on binocular inhibition. How is this effect of attention used in microscopic work?

*3. Give a physiological explanation for the phenomenon of binocular fusion.

9. Absolute Threshold for Color (9)

Materials: Color-wheel.[1] Large discs of white, red, yellow, blue, and green. Small disc of white. Measuring disc.

Method: The purpose of this experiment is to find the least amount of color that can be seen. The experimenter places a red disc and the large white disc interlapped upon the color-wheel, and upon these the small white disc. Arrange the large discs so that a very small amount (about one half of a degree) of red is exposed. Revolve the wheel at a rate sufficient to produce a uniform surface. The subject reports whether he sees a difference in hue (color) between the inner and the outer discs. If no difference is observed, slightly increase the amount of red and repeat. Continue this procedure until the subject, by comparing the inner and outer discs as they revolve, can detect the presence of red in the outer disc. Measure in degrees the amount of red required.

Now add an amount of red sufficient to make the hues of the two discs plainly different. Decrease the red until the subject reports that the two discs seem identical. Measure the amount of red which remains exposed.

Repeat each procedure five times.

The threshold is now found in a similar manner for the other three colors.

Record: For each color the averages of the five trials with increasing color, and the five trials with decreasing color are taken separately. The average of these two averages then gives the absolute threshold for the color used.

[1] The Milton-Bradley color tops and discs may be substituted.

Tabulate the measurements as follows:

TRIAL	RED		YELLOW		GREEN		BLUE	
	INCREASE	DECREASE	INCREASE	DECREASE	INCREASE	DECREASE	INCREASE	DECREASE
1								
2								
3								
4								
5								
AVG.								
FINAL AVERAGE (ABSOLUTE THRESHOLD)								

Questions: 1. Name the colors in decreasing order of their thresholds.

2. If the average measurements for increasing and for decreasing the color are unequal, give the reason for their inequality.

3. Why is one unable to detect a smaller amount than the threshold stimulus?

4. State the possible causes for the individual differences that exist in threshold for color.

5. What change, if any, occurred in the outer white of the discs before the color was observed? Explain.

*6. A difference in the sensitivity for hues is noticeable in twilight. Observe and describe the order in which the different hues of objects disappear as night approaches.

7. Up to a certain limit the longer the eye is shielded from light the more sensitive it becomes to low light intensities. This is called dark adaptation. Observe and describe a phenomenon which illustrates this point.

II. AUDITION

1. Lower Threshold for Sound (10)

(*Class experiment*)

Materials: Watch. Measuring tape.

Method: The subject sits erect in a straight-backed chair and keeps his head in a constant position throughout the experiment. Beginning one foot from his left ear move the watch very slowly and noiselessly away until the subject no longer hears its ticking. The distance of the watch from the ear is then measured.

The watch is then held five feet beyond this point and moved slowly and noiselessly nearer until the subject hears it. The distance is again measured. Repeat these two procedures, using the other ear.

Care should be taken to keep the face of the watch turned squarely toward the subject's ear. After the threshold is obtained, hold the watch still at a point slightly within the threshold. The subject notes whether he hears any fluctuations in the intensity of the sound. The experiment should be performed on as many members of the class as time will permit.

Record: (*a*) Present in tabular form the "in" and "out" thresholds and their average for each ear, and for the different subjects chosen.

(*b*) Give a rough estimation of the time and period of the fluctuations of intensity, together with a statement of whether this rate seems to be correlated with the rate of the subject's respiration.

Questions: 1. Judging from your results what do you consider the range of normal individual variability in the lower threshold for sound?

2. What are the possible causes for the fluctuations in intensity which you observed?

3. Would you call the tick of a watch a tone, or a noise, or both? Give several examples of auditory perceptions commonly called "noise," but in which tones are distinguishable.

2. Differential Threshold for Pitch (11)

(*Class experiment*)

Materials: Two tuning forks of the same pitch, set on resonance boxes. Rubber hammer. Beeswax. Small cardboard screen. Watch with second hand.

Method: The tuning forks are concealed from the class behind the screen. The experimenter strikes the two forks successively to familiarize the subjects with their quality. The subjects note that the forks are of equal pitch. The experimenter then places a very small piece of wax on one prong of one of the forks near the top. The forks are again struck successively with equal intensity, and the students indicate by show of hands: (1) the number of subjects who judged the two sounds equal in pitch; (2) the number who judged the second sound lower; and (3) the number who judged the second sound higher. Small quantities of wax are added as required, thus further lowering the pitch, until, when the forks are struck successively, seventy per cent of the subjects give the correct judgment as to the difference in pitch of the forks.

Sometimes the loaded fork is struck first, and sometimes the other, in no regular order. In all the trials the first fork is allowed to sound for two seconds, and then dampened by placing the hand over the prongs.[1] Then after an interval of two seconds the other fork is struck and allowed to vibrate for the same length of time.

After the seventy per cent of correct judgments have been given the forks are struck in quick succession without dampening. They will then beat: that is, there will be a rising and falling in the intensity of the sound. The number of these beats per second depends upon the difference in number of vibrations per second between the forks. For example, five beats per second indicates a difference in pitch of five vibrations per second.

In order to find the threshold of difference for pitch the beats are

[1] To prevent rusting the steel avoid touching the fork with the bare hand. It is advisable to wear a glove or hold a cloth in the hand.

counted for five seconds by the class. The count of ten members of the class is taken.

The variable fork is now weighted sufficiently to produce more than the just noticeable difference in pitch, and the forks struck as at the beginning. The wax is then diminished until less than seventy per cent of the class give correct judgments as to the difference in pitch. When this point is reached the beats are counted as before.

If time permits, the threshold can be found using forks of considerably higher or lower pitch than those used in this experiment. These thresholds at the different pitches can then be compared with the results obtained later under XI ("The Psychophysical Law").

Record: Tabulate the beat counts of the ten members of the class for five seconds and take the average. Divide this again by five to obtain the average number of beats per second.

This is to be done separately for the two procedures, one of raising, and the other of lowering, the variable fork. The final average is then taken. This average is the threshold for difference in pitch at the pitch of the forks used.

Questions: 1. What individual factors can you think of which might influence the threshold for pitch difference?

2. What analysis can you give from your introspection of the method of comparison by which you judged the equality and difference of the two tones?

***[1]3. Tonal Fusion** (12)

(*Class experiment*)

Materials: Pianoforte or organ; or two sets of tuning forks each set consisting of a root, major second, major third, fourth, fifth, major seventh, and octave. For example, such a set might comprise the tones *c*, *d*, *e*, *f*, *g*, *b*, and *c* (*octave*). If tuning forks are used, they should be hidden by a screen from the subjects. Two rubber hammers are required for striking the forks.

Method: The experimenter strikes the various intervals in such a way that the class cannot see the operation. The students indicate by show of hands those who can distinguish the two tones of the chord. The judgment should be made, not as to whether it sounds like an interval, but as to whether the two tones are heard as distinct. Occasionally the experimenter strikes only one tone, but somewhat louder, as a test of the reliability of the judgments. The number of students who do not hear the two tones as separate, in other words, who experience complete fusion, is noted down after each interval. The intervals are given in irregular order, repeating until each has been sounded five times.

Care should be taken to strike the two notes of the interval with equal force. If pairs of forks are used they must be sounded simultaneously with the two hammers. They should rest on fairly firm bases.

[1] Experiments which cannot be done without expensive or complicated apparatus are starred.

Record: Present the class judgments in the following tabular form:

INTERVALS		OCTAVE	FIFTH	FOURTH	THIRD	SECOND	SEVENTH
VIBRATION RATIOS		1 : 2	2 : 3	3 : 4	4 : 5	8 : 9	8 : 15
NUMBER OF SUBJECTS OBTAINING FUSION	TRIAL 1						
	2						
	3						
	4						
	5						
	AVG.						
PER CENT OF CLASS OBTAINING FUSION							

Questions: 1. What correspondence do you find between simplicity of vibration ratio and degree of fusion as indicated by the per cent of individuals obtaining the fusion experience?

2. Do your results confirm or refute Stumpf's theory of consonance?

3. What indications, if any, are there in your results of practice effect?

4. Binaural Pitch Difference (13)

(*Class experiment*)

Materials: Two tuning forks of equal pitch, such as C_2 or A_1. Beeswax. Rubber hammer.

Method: The subject sits in a chair and closes his eyes. The experimenter has an assistant hold the two forks opposite and close to the two ears of the subject at equal distances. He then strikes one of the forks and after three seconds dampens it by placing his hand across the top of the two prongs. The other ear is closed. The tuning forks are to be held with their prongs parallel to the side of the head. Immediately after dampening the first fork, the experimenter strikes the other with as nearly as possible the same force, and dampens it after three seconds. The subject judges whether the two forks seem of equal or of different pitch. This is repeated until there is no doubt of the correctness of the judgment.

Repeat this preliminary experiment on as many members of the class as time allows.

Now select the subject who notices most decidedly a difference. Strike the tuning forks as before, the subject indicating which sounds the higher. Place a small piece of wax on one of the prongs of this fork near the top. The forks are now sounded again and the judgment given. If the altered fork still sounds higher to the subject, add more wax; if lower, remove a small amount, until the two forks seem of equal pitch.

It is now necessary to find the objective pitch difference of the forks. The experimenter sounds them together and the class counts the beats for five seconds, starting at an even second mark. The counts obtained by five members of the class are taken and averaged.

Record: (*a*) Present a table of the subjects experimented upon indicating whether their two ears were of the same or different pitch.

(*b*) Tabulate the beat counts of the five members of the class for five seconds, the average of these five counts, and finally the aver-

age for one second. This last expresses in number of vibrations per second the pitch difference of the two ears for the last subject.

Questions: *1. What fraction of a musical whole tone (major second) does this pitch difference represent? Compute this from the vibration rate of the unloaded fork, and the rate of its major second which may be obtained by using the ratio given in the preceding experiment. [C_2 has 528 v. per second. A_1 has 440.]

2. Judging from what you have already done in obtaining thresholds of sensation, would you say that this method for measuring the pitch difference is complete? If not, how would you proceed further?

3. How may the æsthetic pleasure of the subject be affected by his binaural pitch difference? Are all individuals having pitch difference thus affected? If not, why?

4. Judging from your results what tentative estimate can you make as to the frequency of the occurrence of pitch difference?

5. What other evidences of sensory differences between right and left organs have you observed in sound and in vision?

III. SMELL

1. Exhaustion and Recuperation (14)

Materials: Small bottles of tincture of iodine and spirits of camphor. Watch with second hand. Wide bottles should be used so that about one square inch of the liquid surface is exposed.

Method: The subject holds one nostril closed and, holding the bottle of iodine about a quarter of an inch from the other nostril, inhales evenly and rapidly and exhales through the mouth. Continue until the odor can no longer be smelled. The experimenter notes the time required for this exhaustion. A thirty second rest period is now allowed with both nostrils open. The subject then smells the odor as before through the same nostril until the organ is again completely exhausted. The time is again noted. Continue this process of exhaustion and recuperation until no odor can be detected after the half minute rest period.

Using the other nostril, repeat the experiment with spirits of camphor.

Record: Tabulate the series of successive exhaustion times for camphor, and the series for iodine.

Questions: 1. From a comparison of the two series what law can you formulate as to the relation of the number of successive exhaustion periods to the initial exhaustion time?

2. Which of the two olfactory processes used would sooner *fully* recuperate?

3. This experiment illustrates complete exhaustion (for certain end organs). Describe an experiment which would demonstrate olfactory adaptation,— that is, a condition in which the organ no longer responds to the given intensity of stimulus, but may respond to a greater intensity.

4. After the odor disappeared, did the subject notice any other sensations? If so, describe them.

2. Selective Exhaustion (Qualitative) (15)

Materials: Small bottles of three odors, such as nitro-benzole, oil of camphor, eau de cologne, oil of turpentine, oil of lavender, oil of bergamot, or any other compound odors which yield different olfactory qualities if smelled for some time. A watch with second hand.

Method: The subject smells the odor with one nostril as in the preceding experiment, and notices any changes which occur in the quality of the odor. The experimenter notes down these qualities and takes the time at which the changes occur. Repeat the experiment, using the other two odors.

Record: For each odor state the qualitative changes which occurred, their duration, and the total exhaustion time.

Questions: 1. What does this experiment indicate in regard to the structure of the olfactory organ?

2. If you had a mixture of alcohol and a less quickly exhausting odor x (these two odors forming a perfect fusion), how could you determine x by olfactory means? Give two methods.

3. Selective Exhaustion (Quantitative) (16)

Materials: Small bottles of iodine, spirits of camphor, oil of turpentine (ol. terebinthi), oil of cloves (ol. caryophyllorum), oil of bergamot, oil of lavender, and eau de cologne.

Method: With one nostril closed, the subject smells successively of the last five odors (as named above) and estimates the intensity of each one separately on a subjective scale of five, — one being the lowest in intensity, five the highest. A general idea of the range of this scale should be obtained by smelling each of the odors briefly with one nostril before beginning the experiment. The estimation of the five odors is made three times.

The subject now exhausts the same nostril for iodine, and smells the five odors again in the same order, estimating their intensities in three trials as before.

Repeat the experiment with the other nostril, using spirits of camphor for the exhausting odor.

Record: Arrange the estimations in the form of the table given below.

ODOR	TEREBINTH		CARYO-PHYLLORUM		BERGAMOT		LAVENDER		COLOGNE	
	IODINE EXHAUSTION									
TRIAL	BEFORE EXHAUST-ING	AFTER EXHAUST-ING	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1										
2										
3										
AVG.										
DIFF. < or >										
	CAMPHOR EXHAUSTION									
1										
2										
3										
AVG.										
DIFF. < or >										

< means intensity was greater before exhausting.
> means intensity was greater after exhausting.

Questions: 1. What conclusions can you draw from the results of this experiment?

2. When a mixed substance gives an olfactory sensation in which you do not recognize separate odors, there are two possibilities. Either there is a fusion of the component odors, or one odor inhibits the other. Supposing such an odor is stronger after than before selective exhaustion, — how do you explain it? Supposing it is weaker?

*3. In this experiment you have discovered the components of compound odors by analysis. Describe an experimental method of examining fusion and inhibition synthetically.

4. What practical use is made of the phenomenon of olfactory inhibition?

5. Describe an accepted method of obtaining the absolute olfactory threshold.

IV. TASTE

1. Taste and Smell Fusions (17)

Materials: An onion. An apple. Milk. Water.

Method: (1) Cut very small pieces from the onion and from the pared apple. The subject closes his eyes and holds his nostrils. The experimenter then places on the subject's tongue one of the prepared pieces. The subject observes the taste and then removes the piece. The experimenter now places the other substance on the tongue of the subject, who states what difference, if any, he noticed in the two taste sensations.

Repeat with the nostrils open, describing the quality of the sensations resulting from the two substances.

(2) The subject takes a swallow of milk while holding his breath, and observes the quality of the sensation. He then quickly takes several swallows of water before finally exhaling. He now takes a swallow of milk and exhales immediately, and compares the quality of this sensation with that of the previous one.

Record: Present an introspective account of the different qualities of the onion, apple, and milk under the different conditions.

Questions: 1. How do you explain these qualitative differences in the sensations resulting from the same substance?

2. Give an account of the different sensory qualities and the different senses involved in the so-called "taste" of lemonade.

3. Name at least three substances which could be used to bring out the point of this experiment.

V. TOUCH

1. Location of Touch End Organs (18)

Materials: Boar's bristles. Wooden skewers. Reading glass. Sealing wax. Small, fine-pointed scissors. Ink pad. Rubber stamp which makes an impression of a three quarter inch square of dots. There are in all 49 dots placed one eighth inch apart in seven rows, which are also one eighth inch apart, as shown in figure 3.

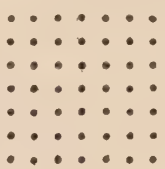
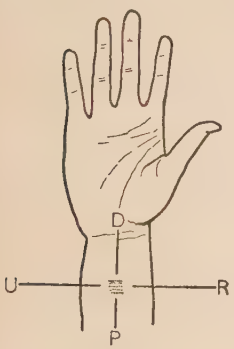


Fig. 3.

Method: Make an imprint of the rubber stamp on the palmar side of the subject's lower forearm, about two inches from the wrist. Make three reproductions of this square to a convenient scale on cross section notebook paper, as shown in figure 5 below, labeling the four directions R, U, D, and P, which are explained in figure 4. With the aid of the reading glass locate any hairs within the stamped area, and after indicating their location on each of the three notebook maps by crosses, cut them away close to the skin.



P = PROXIMAL
D = DISTAL
R = RADIAL
U = ULNAR

Fig. 4.

Select a bristle of such length and thickness that when applied vertically to the skin, it will just give a touch sensation. If the end is split, it must be cut off squarely. By means of sealing wax fasten the thicker end of the bristle to the blunt end of the skewer in such a way that the bristle and skewer form a right angle.

With eyes closed the subject rests the forearm, palmar side up, comfortably on the table. The experimenter touches the dots lightly and with uniform pressure, holding the bristle in a position

vertical to the skin. He explores the map, starting at the radial end of the most proximal row of dots, and taking the rows successively, beginning always at the radial side. Allow about two seconds between successive stimulations. Whenever the subject feels a touch sensation he gives a signal. Locate these 'touch spots' on the first of the three notebook maps, using a circle to signify the usual touch sensations and a square to denote those which are especially vivid.

This procedure is repeated, the experimenter moving from proximal to distal on each row and taking the rows successively from the radial to the ulnar side. Locate the spots found in the second map. The experimenter should exercise care not to touch the subject's hand with his own while stimulating the dots.

The student must understand that the method of stimulating only dots is purely arbitrary and for convenience. It is possible that there are touch organs between these dots, so that the number of touch organs located is only an approximation.

Record: Present the two maps already described, and a third map on which should be indicated by small triangles the verified touch spots, that is, those which yielded touch sensations in each of the two previous maps.

Figure 5 shows the arrangement of the three maps (for the right forearm) together with a sample record. The arrow indicates the direction of stimulation.

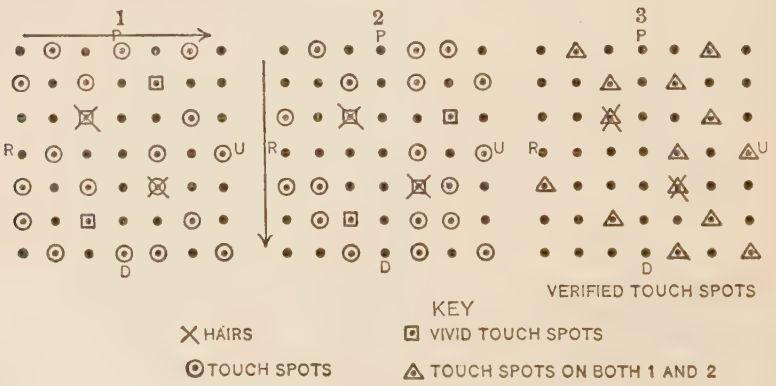


Fig. 5.

Questions: 1. What relation, if any, do your results indicate between hairs and touch sensations? If there were too few hairs in your map to judge, answer this question by stimulating hairs on other parts of the arm.

2. Explain physiologically the function of the hair in touch sensations.

3. What does this experiment show in regard to the anatomical basis of touch?

4. What biological reason can you give for the fact that touch spots are more numerous on mobile extremities of the body than elsewhere?

5. Why do some spots yield more vivid sensations than others?

6. What are the possible sources of error in your results?

2. After Image (19)

Materials: A wooden skewer. Watch with second hand.

Method: The experimenter taps the subject's forehead smartly with the blunt end of the skewer. The subject attends to the throbs or resurgences which follow the first touch sensation. These are the so-called after images. Their number, quality, and total duration are noted.

Record: (1) State the total time of the duration of the series of after images, and the rate (approximately) of their recurrence.

(2) Give a comparison of the intensity, spacial extent, and duration of the succeeding after images with these aspects of the original sensation. State also any other qualitative differences that may be noticed.

Questions: *1. What explanation can you offer for this intermittent after-sensation?

2. Where have you previously noticed such intermittent sensory phenomena?

3. Exhaustion (20)

Materials: Skewer with bristle attached as in the first touch experiment.

Method: The experimenter explores the back of the subject's hand with the bristle until a well-defined and rather isolated touch spot is found. It should not be too near a hair. This spot is then enclosed with an ink circle about one millimeter in diameter. The subject closes his eyes, and the experimenter touches the spot squarely and rhythmically with equal pressure, and rapidly enough to prevent recovery of the end organ between stimulations. This is continued until the subject no longer feels a touch sensation. The number of touches required is noted. Be careful always to touch the exact center of the circle.

Record: (1) State the number of stimulations necessary to exhaust the touch organ.

(2) Write a general description of any changes in intensity which the subject experienced during the stimulation.

Questions: 1. How do you explain any fluctuations in intensity which you may have noticed?

2. What possible sources of error can you point out in your experiment?

4. Adaptation (21)

Materials: Two equal weights of about 50 grams. A lighter weight of about 15 grams, and a heavier weight of about 100 grams. The materials of experiment XI, 2, may very well be used in this experiment.

Method: The subject closes his eyes and extends his two hands palms up on the table. The experimenter places the two equal weights simultaneously on the hands of the subject, who notes that they appear equal in weight. The two unequal weights (light and heavy) are then placed simultaneously, one on each palm. They are raised and lowered by the experimenter on the same spot of their respective hands twenty-five times.

The experimenter now quickly replaces the two equal weights, one on each palm. The subject indicates whether they still seem equal.

Record: Give a comparison of the feeling of the two equal weights before and after the application of the unequal weights.

Questions: 1. What effect does adaptation to pressure have on the estimation of a weight?

*2. What is a possible physiological basis of this change in judgment?

3. Give several examples of the effect of adaptation upon the judgment of the stimulus.

VI. WARMTH

1. Location of Warm End Organs (22)

Materials: Metal rods about six inches in length with points which are slightly rounded. These rods can be made from round brass rod five thirty-seconds of an inch in diameter. Tumblers. Very soft pencil. Facilities for heating water.

Method: The rods are to be kept in a glass of very hot water which should be repeatedly renewed as it cools. Preliminarily to the experiment, the experimenter touches the subject's forearm in different places with the point of the heated rod, in order to enable the subject to distinguish between the sensations of warmth, heat, and pain.

The subject's arm is now extended palm up with the fingers toward the experimenter. With the aid of a ruler and a very soft and fairly sharp-pointed pencil a line six inches long is drawn lengthwise on the palmar surface of the subject's forearm. With the point of a heated rod the experimenter stimulates the skin along the line in the distal direction by making successive applications about one millimeter apart and with an interval of two seconds between stimulations.

The subject indicates when he feels sensations of warmth or heat, and the experimenter marks the exact location of these sensitive spots by small dots along the line. Place the dots for warm sensations on the right, and those for heat on the left of the line. Spots yielding cold sensations should be especially designated. This last is known as 'paradoxical cold sensation.'

Throughout the experiment the rods should be kept warm enough to give a temperature sensation when applied lightly to the skin, but not so hot as to produce the sensations of burning or pain. Always see that the point of the rod is dry before touching it to the skin.

Repeat the experiment, stimulating the line in the proximal direction, and marking the spots that give temperature sensations as before. This time place the dots a little further out from the line so they will not be confused with the row already made.

Record: (1) Transfer the line with the rows of dots to the notebook, indicating with arrows the directions of stimulation of the rows, and designating the proximal and distal ends.

(2) Make a second line in the notebook, putting in those temperature spots which were found to coincide when working in the two directions. Almost identical spots may be considered as coinciding.

Questions: 1. Were any sensations of cold experienced? How would you explain cold sensations obtained in this experiment?

2. Judging from your introspection, is the sensation of heat a more intense warmth sensation, or a fusion of different qualities? If the latter, what qualities?

2. Local Variations in Sensitivity (23)

Materials: Metal rods and hot water as in the preceding experiment.

Method: With the blunt end of the heated rod the experimenter stimulates the subject's palm and the back of his hand in such quick succession that the rod will not have time to cool between the two stimulations. Heating the rod as before, stimulate in quick succession the palm and the center of the forehead; then the center and side of the forehead; then the nose and chin. The subject indicates the intensity of each sensation on a scale of one to five.

Record: Tabulate the degree of intensity of the warmth sensation for each location, arranging the regions stimulated in decreasing order of their sensitivity.

Questions: 1. How do you explain the fact that the same intensity of stimulus feels warmer in one place than in another?

2. What ordinary experiences relate to the facts of this experiment?

3. Adaptation (24)

Materials: Tumblers of hot, cold, and lukewarm water. A supply of hot water.

Method: The subject holds the right index finger in the cold water and the left index finger in the hot water simultaneously for two minutes. He observes the change in the temperature sensations of the two fingers during two minutes' adaptation. He then places the two index fingers quickly in the lukewarm water and notes the difference in the temperature sensations of the two fingers.

Repeat the experiment, using the right and left middle fingers, but holding them in the hot and cold water this time for only one minute. The time is kept by the experimenter.

Record: (1) Describe and compare the changes in temperature sensations as the right and left index fingers become adapted to the hot and cold water.

(2) Describe the temperature sensations experienced by the two index fingers when placed in the lukewarm water.

(3) Compare approximately the effect of the one-minute with that of the two-minute period of adaptation when the fingers were placed in the lukewarm water. State whether the increase in contrast seemed proportional to the increase in length of adaptation.

Questions: 1. Why do we call this experiment adaptation rather than exhaustion?

2. Compare this phenomenon to a similar one we have studied, showing the similarity and the difference.

3. Give several examples of adaptation to warmth in everyday life.

VII. COLD

1. Location of Cold End Organs (25)

Materials: Metal rods. Tumbler of ice water. Ruler. Soft pencil.

Method: Using rods cooled in the ice water follow the same procedure as in the location of warmth end organs (VI, 1). The line should be as nearly as possible identical with the line used in that experiment. Use one side of the line to locate the cold spots for the distal direction of stimulation, and the other side for the proximal. Unusually vivid cold spots and spots giving paradoxical warmth sensations (that is, a warmth sensation arising from a cold stimulation) should be especially designated.

Record: Transfer the line to the notebook and make a verification line, as in the experiment in warmth.

Questions: 1. What is the ratio of warmth to cold spots in the region you have investigated?

2. What are the probable sources of error in this experiment?

3. Give an explanation for any especially vivid cold sensations you may have found.

4. Do your results in the last few experiments support the theory that heat is a combination of warmth and cold?

5. From your introspection compare the qualities of warmth and cold.

2. After Image (26)

Materials: Pennies. Tumbler of ice water.

Method: The experimenter cools a coin in the ice water, and then dries it thoroughly and holds it for three seconds against the subject's forehead. The subject attends to the resurgences which follow the first cold sensation. The number, quality, and total duration of these after images are noted. Care should be taken to distinguish between the after images of cold and touch.

Record: (1) State the total time of the duration of the series of after images, and the rate of their recurrence.

(2) Compare the intensity, spacial extent, and duration of the succeeding after images with these aspects of the original sensation. Describe any other qualitative differences which may be noticed.

Questions: 1. How does the relation of intensity of after image to intensity of sensation in this experiment compare with that in the after image of touch?

2. Although the coin is thoroughly dry the after image is often described as wet. How do you account for this?

3. Inhibition of Cold and Warmth (27)

Materials: Metal rods. Tumblers of hot and cold water.

Method: A. Successive. Stimulate the back of the subject's hand with a cold rod, and three seconds afterward with a heated rod at a distance of about six centimeters (two and one half inches) from the first stimulation. Note the effect of the second stimulus. Repeat, reversing the order of cold and warmth stimulations.

B. Simultaneous. Apply the warm and cold stimuli at the same time and at a distance of about six centimeters. The subject observes the resulting sensation.

Record: For A, state the effect of the one stimulation on the sensation from the other. For B, describe the sensation which results from the simultaneous stimulation of warmth and cold.

Questions: 1. In A, if the last stimulation always inhibits the first, what is the reason?

2. In B is there a tendency for one temperature sensation to inhibit the other? If so, how do you account for it?

*3. In B what would you have said, *a priori*, were all the possible results of such simultaneous stimulation?

4. How do you explain inhibition in the temperature senses?

4. Latent Period (28)

Materials: Metal rods. Needle. Tumblers of hot and cold water.

Method: With a cooled metal rod the experimenter finds a well-defined cold spot on the subject's hand. As he stimulates it the subject notices, with closed eyes, whether touch or cold is felt first.

Similarly, with a heated rod find whether touch or warmth appears first; and with a needle whether touch or pain. The subject observes also the latent periods of warmth, cold, and pain as compared with each other. [Latent period is that time which elapses between a stimulation and the resulting sensation.]

Record: (1) State the comparison of the latent period of touch with the other three senses separately.

(2) Arrange warmth, cold, pain, and touch as accurately as you can in decreasing order of the length of their respective latent periods.

Questions: 1. How do you account for these differences in latent period?

2. Do we commonly notice these dual sensations resulting from single stimulations in ordinary experience? If not, why?

VIII. PAIN

1. Location of Pain End Organs (29)

Materials: Needles. Rubber stamp and ink pad as in the experiment on location of touch spots (V, 1).

Method: Make an impression of the stamp on the under side of the subject's forearm and stimulate the dots in the same manner as you did in the location of touch end organs, except that a sterilized needle is used instead of a bristle. The experimenter must make sure that the point of the needle has not been blunted. The needle is applied slantingly to the skin and with sufficient pressure to indent the skin but not to pierce it.

Record: The spots sensitive to pain are to be given on three maps in a manner similar to that for touch end organs.

Questions: 1. In this experiment does the sensation of pain ever occur without that of touch? What are the possible explanations?

2. From an introspective analysis tell how a pain sensation differs from a touch sensation.

3. How does the numerical ratio of touch and pain end organs as found in your experiment compare with the ratio as reported in the literature? How can you account for any disagreement you may find?

IX. LABYRINTHINE SENSE

1. Sensations of Bodily Rotation (30)

Method: The subject with eyes closed revolves six or eight times on the ball of his foot, gradually increasing and then gradually decreasing his speed. He observes any change in the apparent direction of movement during and after rotation. This is repeated with eyes open, and the experimenter notes the eye movements of the subject during and after rotation. [The eye moves slowly in one direction and jerks back quickly.] The subject takes note of the directions in which he and the surroundings seem to move during and after rotation.

The rotation is again repeated with the eyes open, the subject fixating the eyes at the end of their slow movement, thus inhibiting the quick forward movement (which alone can be inhibited). Note that there is no sensation of dizziness.

Record: State in tabular form:

(1) The various apparent directions of rotation with eyes closed.

(2) The various apparent directions of rotation and movement of the surroundings with eyes open.

(3) The eye movements during and after rotation.

Questions: 1. Explain physiologically the variations in the apparent direction of rotation with eyes closed.

2. Give an explanation of the apparent movements of the surroundings with eyes open.

3. What do you judge from your experiment to be the cause of dizziness?

4. You have doubtless had the experience when objects were moving past you that you were yourself moving, although your body was stationary. Describe two such instances and explain them from what you have learned in this experiment.

5. Name the factors by which you perceive motion of the body in a straight line with eyes closed.

X. KINÆSTHETIC SENSE

1. Sensations of Active and Passive Movement (31)

Materials: A piece of white cardboard about two feet square.

Method: On the sheet of cardboard the experimenter draws a quadrant whose radius is the distance from the subject's elbow to the tip of his middle finger. He then lays off the degrees of the arc in steps of ten, as shown in figure 6.

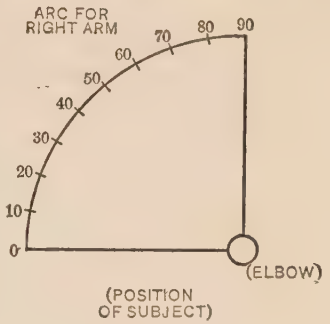


FIG. 6.

A. Passive Movement. The subject places his arm on the arc with his elbow at the center and his middle finger at zero°. He then looks carefully at the arc to fix in mind the positions of the different degrees. After this is accomplished he closes his eyes and relaxes the muscles of the arm. Using the elbow as a pivot the experimenter moves the subject's arm by the wrist through a certain arc of the quadrant, stopping with the middle finger pointing to one of the degree marks. The subject with his eyes still closed judges the distance moved in degrees. The experimenter makes a note of the actual and the estimated amount of the movement.

This is done ten times over varying distances, the subject being kept in ignorance of his errors. The subject is to note the quality of the kinæsthetic sensations.

B. Active Movement. This procedure is the same, except that the subject moves his own arm a certain distance and before opening his eyes estimates the movement in degrees. He should not have in mind beforehand a definite degree at which he is to stop. Again he notes the quality of the movement sensations. The experimenter notes down the actual and estimated movement as before. The

subject, after making his judgment and before opening his eyes, should move his arm, so that he does not perceive the amount or direction of his error. Ten trials are made.

Record: (1) Tabulate under A and B the standard degree and the number of degrees of error in estimation for each trial, indicating whether the error is plus or minus. State the average of all the errors in A, and the average of those in B, irrespective of signs.

(2) Present the number and the average of the plus errors and the number and average of the minus errors in A. Do the same for B.

Questions: 1. Which method is more accurate, A or B? Why?

2. Give reasons for any tendencies which occur in the errors (e.g., a preponderance of plus or of minus errors) in either method.

3. Describe the quality of the kinæsthetic sensations in A and B with special reference to their difference.

4. Is there any evidence of practice effect?

XI. THE PSYCHOPHYSICAL LAW (WEBER'S LAW)

1. The Method in Vision (32)

Materials: Color-wheel.[1] Black and white discs of two sizes. Measuring disc.

Method: The experimenter places a large black and a large white disc interlapped upon the color-wheel, and upon these a small black and a small white disc interlapped. He adjusts both pairs of discs so that 90° of black and 270° of white are exposed. The wheel is revolved to make sure that the two grays (inner and outer) are of the same brightness.

The experimenter now adds a small amount of white to the outer discs and revolves the wheel. [The inner disc remains stationary as a standard throughout the experiment.] The subject reports whether he sees a difference in brightness between the outer and the inner discs. If necessary, continue to add white to the outer disc until a difference is observed upon rotation. Measure the amount of white which *has been added.*

Starting with the outer disc plainly brighter than the inner, decrease the amount of white until subjective equality is obtained. Note in degrees the difference of the white in the inner and outer discs.

Now starting as at first with the outer and inner discs equal, *decrease* the amount of white in the outer until a difference is just perceptible. Note the number of degrees difference as before.

Finally starting with the outer disc plainly darker than the inner, increase the white until subjective equality is reached. Take the measurement as before.

Follow out this entire procedure three times, obtaining in all twelve measurements.

[1] The Milton-Bradley color tops and discs may be used.

The experiment is now repeated, using as a standard (in the inner disc) 180° of white and 180° of black.

Record: Place the measurements in the following tabular form:

TRIALS	STANDARD 270°				STANDARD 180°			
	ABOVE STANDARD		BELOW STANDARD		ABOVE STANDARD		BELOW STANDARD	
	INCREASE W	DECREASE W	DECREASE W	INCREASE W	INCREASE W	DECREASE W	DECREASE W	INCREASE W
1								
2								
3								
AVG.								
AVG. ABOVE AND BELOW STANDARD								
FINAL AVERAGE	THRESHOLD OF DIFFERENCE AT 270°				THRESHOLD OF DIFFERENCE AT 180°			

Questions: 1. Arrange your results so as to show whether they confirm Weber's Psychophysical Law.

2. Obtain the results of other members of the class and find whether their average confirms the law.

3. Discuss the possibilities of error in your results.

4. Give other instances where you observe the operation of the psychophysical law in vision.

2. The Method in Touch (33)

Materials: Balance or letter scale. One hundred no. 3 black burrs (or washers) as shown in figure 7, having the diameter of the hole one quarter inch and the outer diameter five eighths inch. Two holders made from wooden skewers or round sticks, less in diameter than the hole of the burr and about 5 inches in length, to each of which is tacked a disc of stiff cardboard $1\frac{1}{2}$ inches in diameter, as shown in figure 8. Weigh the holders on the scale or balance and, if they are not exactly equal, whittle one of the handles down until they are of equal weight.

FIG. 7.

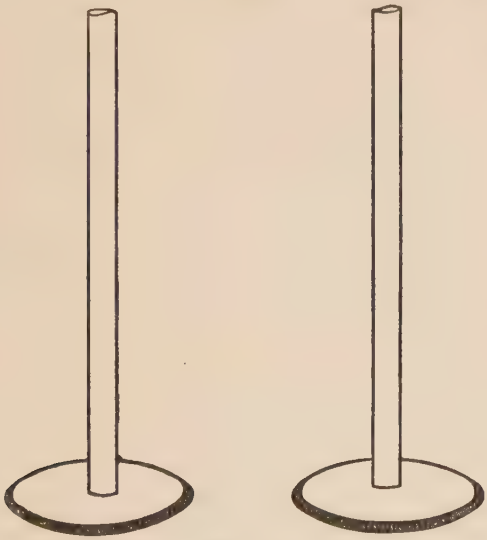


FIG. 8.

Method: Find the approximate weight of a holder in terms of number of burrs. The experimenter slips five burrs on each holder and proceeds to find the number of burrs which he must add to one of the holders in order that the subject may feel a difference between the two weights. That is, he is to find the threshold of difference for pressure having as a standard the weight of five burrs plus the weight of the holder in terms of burrs. If the holder is equal in weight to three burrs, the standard is in this instance eight burrs.

This standard weight is kept constant throughout the experiment. The other is called the comparison weight. The subject, with eyes closed, now rests his open hand comfortably on the table,

palm upward. If desired, he may support it on several books. The experimenter places one burr more on the comparison holder and then rests the holders alternately on the open palm. The holder should be allowed to rest on the hand for two seconds and removed, and then an interval of two seconds allowed before the other holder is applied. Rest the holder always on the same part of the palm, and avoid dropping or pressing it against the hand. The subject says whether the second weight feels lighter or heavier than the first.

After about five seconds a second trial is made and the subject reports as before. Continue this procedure for ten trials, placing sometimes the heavier, and sometimes the lighter holder on the hand first, in no definite order. If seven out of ten of the subject's judgments are correct, you may infer that the threshold of difference has been reached. [Seven out of ten is considered a sufficient proportion to eliminate the possibility of chance.] If more than three errors are made, add another burr to the comparison holder and proceed as before. If necessary add still another burr and repeat the ten trials a second time, and so on until the subject is able correctly to detect the difference in seven trials out of ten. The experimenter then notes the threshold of difference in terms of burrs.

The experimenter now makes the comparison holder three burrs heavier than this threshold and applies the holders to the hand as before, the subject judging each time whether the second weight is heavier or lighter. If more than seventy per cent of his answers are correct, the experimenter removes one burr and repeats. Continue this procedure until the weight is reached at which three or more incorrect judgments are made in the ten trials. The threshold of difference as obtained by this method is noted.

The entire experiment is now repeated with the constant holder containing twenty-five instead of five burrs. The standard will in this case be considered as twenty-five plus that number of burrs which are equal in weight to the holder.

At no time during the experiment should the subject be allowed

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to become tired. Rests should be given whenever required to offset fatigue. The subject may open his eyes occasionally between trials.

Record: (1) State the average of the two thresholds at the lower standard, obtained by "coming in" toward the standard and by "going out" away from the standard respectively. Give the average also of the thresholds at the higher standard.

(2) Present the ratios of these final thresholds of difference to their respective standard weights.

Questions: 1. Do your results conform to Weber's law? If not, give reasons why.

2. In what two ways does the method used in this experiment differ from that of the preceding? Which of the two experiments do you consider more accurate? Why?

3. Why was it necessary to allow an interval between the applications of the standard and the comparison weight?

4. What was the purpose of presenting the standard and comparison weights in "no regular order" in the successive trials? This involves the so-called "time error." What would be meant by "space error" in threshold work?

*5. Explain the reason for the "in" and "out" method of procedure.

*6. What other ways of procedure have psychologists found useful in obtaining the threshold of difference?

7. Find out from the literature the various thresholds of difference in the other senses, and describe briefly the instruments and methods by which they may be investigated.

PERCEPTION

XII. PERCEPTION OF SPACE

A. Localization

1. Localization of Sound (one sound) (34)
(*Class experiment*)

Materials: A sound cage. A telephone receiver in series with a battery and telegraph key.[1] The sound cage should be constructed as in figure 9. The horizontal rim of the cage is divided on the inside into steps of twenty degrees beginning with zero° and proceeding to 180° on both right and left sides.

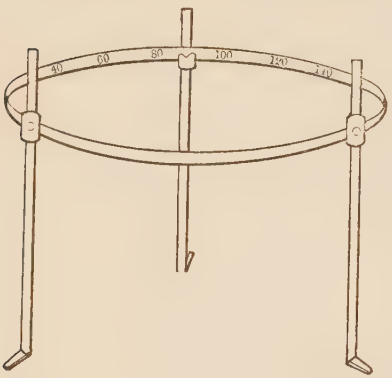


Fig. 9.

Method: The horizontal rim is adjusted to the level of the ears of the subject, who sits with his eyes closed and his ears directly in the center of the rim. He faces the zero mark. The experimenter holds the telephone receiver at the various degrees of the rim, on both right and left sides, in no regular order. An assistant presses the key for each location, and the subject each time judges the location of the click by pointing. The actual and estimated locations are recorded for each trial. The receiver should be moved slowly and noiselessly from one location to another. The subject introspects on his method of localizing the sound.

[1] If the sound cage and telephone receiver are not available, the main facts of this experiment can be brought out by the use of a tuning fork, snapper, or other source of sound. The sound is made at various places around the subject's head, and the direction, both actual and judged, roughly estimated and tabulated.

The experiment is to be repeated on as many members of the class as time allows.

Record: Tabulate the results in the form of the accompanying table. Reversals, such as 180° localized at zero°, or 60° localized at 120°, should be underscored.

SUBJECT:

LOCATION OF STIMULUS SOUND	RIGHT		LEFT	
	LOCALIZATION	ERROR	LOCALIZATION	ERROR
0°				
20				
40				
60				
80				
100				
120				
140				
160				
180				
AVERAGE ERROR			AVG. ERROR	
FINAL AVERAGE ERROR:				

Questions: 1. State the reason for the reversals in the localization of sound.

2. At what degrees was the localization most accurate? Why?

3. If zero° is localized accurately, how do you explain it?

4. What other points in space are likely to be confused with zero° and 180°? Why?

5. Give an exact account of the subject's introspection of his method of localization, including sources of error in localization not already mentioned.

***2. Localization of Sound** (two sounds) (35)

(*Class experiment*)

Materials: Sound cage. Two telephone receivers wired in parallel, with a rheostat in series with one receiver. Two receivers should be selected which give the same quality of sound.

Method: The subject is seated with closed eyes as before. The receivers are sounded successively, varying the resistance until the subject reports that the two clicks seem of equal intensity. The assistant now holds one receiver at 45° on the left side of the subject, while the experimenter places the other at the various degrees of the right side and sounds the key. The subject states whether he hears one sound or two. If one, he localizes it by pointing. The experimenter now holds his receiver at 45° while the assistant places his at the various degrees of the left side. Use either the " make " or the " break " for the sound stimulus. The subject should not be given any clue as to the movement of the receivers.

When two sounds are heard the subject should introspect upon the nature of the resulting spacial perception.

Repeat the experiment, using as many subjects as time allows.

Record: Tabulate the results as follows:

SUBJECT:

RIGHT AT 45° / LEFT AT:	NUMBER OF SOUNDS HEARD	LOCATION OF FUSED SOUNDS	LEFT AT 45° / RIGHT AT:	NUMBER OF SOUNDS HEARD	LOCATION OF FUSED SOUNDS
0°			0		
20			20		
40			40		
60			60		
80			80		
100			100		
120			120		
140			140		
160			160		
180			180		
TOTAL NUMBER OF FUSIONS:					
% OF FUSIONS:					

Questions: 1. Give an explanation of the fusion of two sounds. At what positions is fusion most likely to occur? Why?

2. In what sensory terms was the subject conscious of the space between the two seconds?

*3. What individual differences do you find in the localization of sound? Explain them.

3. Localization of Touch (36)

Materials: Two wooden skewers. Metric rule. Soft pencil.

Method: The subject closes his eyes and extends his left forearm palm upward. The experimenter draws with a fairly sharp-pointed soft pencil a longitudinal and a transverse line (ruled), intersecting at right angles, on the under side of the subject's forearm. The lines should be about six centimeters in length and should bisect each other. The transverse axis is to be called x, and the longitudinal y.

The experimenter now makes a copy of the two axes on cross section paper indicating the four directions: proximal, distal, radial, and ulnar. The subject, with his eyes closed, holds the skewer, near its point, in his right hand which should rest upon his knee. The experimenter with the other skewer touches the point of intersection of the two axes. Immediately after the experimenter's skewer is removed the subject tries to touch the point stimulated with his skewer, holding the skewer down at the first point he touches.

The experimenter measures in millimeters (disregarding fractions) the perpendicular distances from x and from y of the subject's localization, and with these measurements locates accurately in the notebook map the point touched by the subject. Measurements to the right of y are $+$; those to the left are $-$; above x, $+$; below x, $-$. The measurements should also be set down numerically in a table as shown below.

Twenty localizations are to be made and recorded in this manner. In each trial the subject should begin with his right hand resting on his knee. He should observe the various factors by the aid of which he makes his localization. The number of the trial should be placed above the dot in the notebook map. The subject may be allowed to rest and to open his eyes from time to time during the experiment, provided he is careful to turn his wrist over so as not to see the lines.

Record: (1) The measurements are shown in the map as de-

scribed. (2) They are presented in the accompanying tabular form as + or −, under x and y. (3) Take the algebraic sum of the

	DISTANCE FROM X		DISTANCE FROM Y	
TRIAL	+	—	+	—
1				
2				
3				
4				
5				
AVERAGE OF 1st GROUP				
6				
7				
8				
9				
10				
AVG. OF 2nd GROUP				
11				
12				
13				
14				
15				
AVG. OF 3rd GROUP				
16				
17				
18				
19				
20				
AVG. OF 4th GROUP				
FINAL AVG. ALL TRIALS				
ALGEBRAIC SUM (DISTANCE OF CONSTANT ERROR FROM X & Y)				

two final averages under x; and the algebraic sum of those under y. Locate on the notebook map with a cross the point defined by these two measurements. This point represents the constant error of localization of touch on this part of the body, and expresses the average amount and direction of the errors.

Questions: 1. In what direction is your constant error? How do you account for this tendency?

2. Your table gives the averages for each successive five trials. From a study of these what do you conclude as to the effect of practice on the constant error both in direction and amount?

3. Give an account of the subject's introspection regarding the factors which aided him in localization.

*4. Judging from your results in the localization of sound would you say that auditory sensations have a local sign as in the case of touch sensations?

B. Two Dimensional Space

1. Kinæsthetic Perception of Horizontal Linear Space (37)

Materials: A yardstick.

Method: A. Reproduction after Visual Perception.

Place the yardstick on the table horizontally before the subject with the inches reading from left to right. The subject, sitting equidistant between the two ends, selects and names a certain inch mark, e.g. 25, and notes carefully its location on the stick. He then closes his eyes and starting at the left end of the stick runs his right forefinger along the edge until he thinks he has just reached the mark chosen. The experimenter notes down the mark selected and the amount of error, indicating its direction from the mark by + if it is overestimated and by — if underestimated. Before opening his eyes the subject should remove his finger. He should remain in ignorance of both the amount and the direction of his error until the experiment is completed.

This procedure is repeated ten times, the subject selecting the inch marks in no definite order. Three precautions are necessary: (1) The subject must keep his head directed squarely in front while running his finger along the edge. (2) He must maintain a constant speed. (3) The first point at which he stops is to be taken as the result of the trial. No corrections are to be allowed.

B. Reproduction after Visual and Kinæsthetic Perception.

Method A is followed except that the subject, instead of merely looking at the inch marks, draws his finger slowly along the edge with his eyes open until a desired mark is reached. He then reproduces the movement with eyes closed as before. The same precautions are to be observed.

Record: Make two tables in the manner shown, one for A and one for B.

TRIAL	MARK CHOSEN	REPRO-DUCTION	AMT. OF ERROR		% OF ERROR	
			+	−	+	−
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
		AVG.				
AVERAGE (+ AND − TOGETHER)						

Questions: 1. Which method (A or B) gives the more accurate reproduction of the distance? Give an explanation of this fact.

2. Discuss the relation of length of distance chosen to the accuracy of reproduction.

3. Do your results indicate any effect of practice? How might you change the method so as to produce a considerably greater practice effect?

4. Judging from your results would you conclude that the effect of practice in reproducing one distance can be transferred to the reproduction of distances in general?

5. In what situations of life is method A employed? Show the practical application of method B.

2. Kinæsthetic Perception of Vertical Linear Space (38)

Materials: A yardstick.

Method: The procedures A and B are used as in the preceding experiment, except that the yardstick is now held by the experimenter in an upright position before the subject, with the one inch mark at the bottom. The subject reproduces the distances by beginning at the bottom and moving his finger upward along the edge of the stick.

Record: The results are tabulated as in the preceding experiment.

Questions: 1. Is the reproduction of vertical space more or less accurate than that of horizontal? Give an explanation.

2. How do horizontal and vertical reproductions compare in regard to tendencies for (*a*) overestimating the movement, (*b*) underestimating the movement? Answer this question from a survey of both the number of plus and minus errors, and their respective percentile averages.

3. Give an explanation for these tendencies.

*4. Describe a simple modification of this experiment to show whether the error of reproduction is of visual or of kinæsthetic origin.

3. Kinæsthetic Perception of Size (39)

Materials: A wooden stick between 12 and 24 inches in length.

Method: The stick should not be seen by the subject until the experiment is finished. With eyes closed the subject holds the stick endwise between the palms of his hands, noting kinæsthetically the distance by which the hands are separated. The experimenter removes the stick, and the subject then places his hands in his lap for five seconds. With eyes closed he now reproduces the distance, holding his hands as nearly as possible at the same distance apart as when holding the stick. The experimenter measures the error. Ten trials are made. The subject must be kept in ignorance throughout of the amount and direction of his errors. He should introspect upon the method of reproduction.

Record: Tabulate the amounts and the directions of the errors, and find the averages of the plus and the minus errors separately.

Questions: 1. State and give reasons for any tendency shown in the direction of the errors.

2. State and explain the effect of practice in the successive estimations.

3. Give an introspective account of the criteria involved in the estimation.

4. Tactual, Kinæsthetic, and Visual Perception of Form (40)

Materials: Three figures about three-fourths inch in diameter, cut from sheet metal or stiff bristol board. They should be of graded complexity, such as a round disc, a diamond, and a star.

Method: The exact shapes chosen must be concealed from the subject until parts A and B of the method are completed.

A. The subject closes his eyes and extends his left hand palm up. The experimenter places the simplest figure in the middle of the palm and presses it gently so that its edges touch at all points. The figure is then removed and the subject opens his eyes and draws the form as he perceived it.

B. The experimenter now replaces the figure and holds it in place with a pencil. The subject with eyes closed runs his forefinger around the edge. The figure is then removed and the subject draws its apparent shape as before.

C. The subject now looks at the figure and draws it as accurately as possible.

These three procedures are followed with the other forms.

Record: Present the drawings of the different forms under the various conditions.

Questions: 1. What differences do you find in the drawings under A, B, and C? Discuss the causes of these differences.

2. Describe all that introspection affords in perceiving the form by running the finger about the edge of the figure.

3. What evidence have we that practice can improve the tactual and kinæsthetic perception of form?

5. Tactual Perception of Distance (41)

Materials: An æthesiometer, or a pair of dividers to which should be attached bluntly pointed wooden tips. A metric rule.

Method: An ink dot is placed on the under side of the subject's forearm about three inches above the wrist. Starting with the points of the dividers set one half a centimeter apart, the experimenter stimulates the subject's forearm. The two points are applied with equal and constant pressure, lengthwise of the arm, one on either side of the ink dot. The subject, with his eyes closed, states whether he feels one or two points. This is repeated five times. Occasionally only one point is applied in order to test the carefulness of the judgment.

The experimenter proceeds as before, increasing the distance between the points, as required, by small amounts until three or more of the five stimulations yield discrimination of two points. This distance is noted.

Starting with the points somewhat further apart than this threshold, the experimenter gradually decreases the distance until three out of five trials give one point judgments. Note the distance as before.

Make another trial, repeating both "in" and "out" procedures.

One often "knows" that there are two points because he feels a blunt or extended sensation. The subject must not base judgments of two points on this criterion, but must actually perceive the " twoness " of the points.

The entire experiment is now repeated with the points placed crosswise of the arm on either side of the ink dot.

Record: (1) Arrange the threshold measurements you have obtained in the following tabular form:

TRIAL	LONGITUDINAL		TRANSVERSE	
	OUT	IN	OUT	IN
1				
2				
AVG.				
FINAL AVERAGE	LONGITUDINAL THRESHOLD		TRANSVERSE THRESHOLD	

(2) Draw two lines intersecting at right angles and corresponding in length to the two thresholds. Time does not permit finding the thresholds in the other directions about the ink dot. Therefore interpolate these threshold points by drawing an ellipse around the two lines enclosing the area within which any two points are felt as one. See figure 10. This boundary is known as "Weber's Sensory Circle."

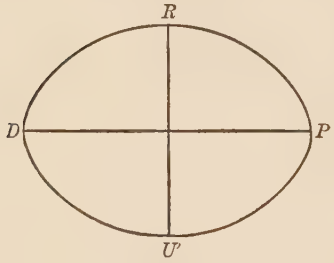


FIG. 10.

Questions: 1. Give a physiological explanation of the threshold for tactual perception of distance.

2. When one point only was felt, was it because of inhibition or fusion? Why? How can you prove this by a further experiment?

3. What factors may influence the size of the threshold?

*4. From what you know of the sense organs of touch what might you infer concerning the size of Weber's Sensory Circle in various parts of the body?

5. Why do we not take the average of the longitudinal and transverse thresholds?

6. Tactual and Visual Perception of Filled and Unfilled Space (42)

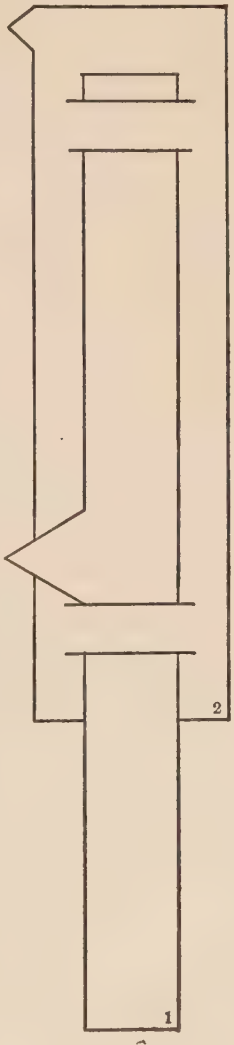
Materials: Two cardboard instruments to give filled and unfilled

(*a*)

FIG. 11.

tactual space sensations, made as shown in figures 11 and 12. In card (*a*) the distance between the points of the two end teeth is $2\frac{1}{4}$ inches. Card (*b*) which consists of a movable strip with a tooth (1) inserted under the two loops of another toothed card (2), should be so constructed that the two teeth can be placed as near together as one inch and as far apart as $2\frac{3}{4}$ inches. The two figures given may be used as patterns. Metric rule.

Method: The subject closes his eyes and extends his forearm palm up. Card (*b*) should be set so that the distance between the movable and fixed points is the same as that between the two end points of card (*a*). The experimenter now takes card (*a*) and presses the teeth longitudinally against the forearm about two inches above the wrist. All the teeth should touch the skin. Immediately thereafter he stimulates the wrist with card (*b*) about one centimeter to one



(*b*)

FIG. 12.

side of the first stimulation. Be sure that the two points touch the arm with the same pressure. The subject judges whether the distance between the two points seems equal to, or greater or less than, the entire length of the row of teeth in card (*a*). If they do not seem equal, the distance between the points of card (*b*) is altered until upon successive applications to the wrist the subject reports equality in the seeming length of the two stimuli. The unfilled distance is then measured and noted, the subject being kept in ignorance of the nature of his error.

Six such trials are made, the experimenter using sometimes the 'out,' and sometimes the 'in,' direction of procedure as followed in former experiments.

Record: Tabulate the amount and direction of the errors as shown in the table. The amount of error is in each trial the difference between the filled and unfilled distances which were judged equal. The direction is + or −. Plus means that the unfilled space is overestimated; minus means that it is underestimated. State also the per cent of the illusion in terms of the filled space.

TRIAL		AMOUNT OF ERROR +	AMOUNT OF ERROR −
	1		
	2		
	3		
	4		
	5		
	6		
AVG.			
% OF ILLUSION			

Questions: 1. Give an explanation of the illusion of filled and unfilled tactual space.

2. Can you overcome the illusion? If so, how?

3. Compare the tactual illusion with the visual, as shown in figure 13.

FIG. 13.

At the left is a row of dots corresponding to the points of card (*a*). At the right is an equal distance of unfilled space. State how

this illusion differs from the tactual, and give an explanation for the difference.

4. Give three familiar examples of the illusion of filled and unfilled space.

7. Optical Illusions of Space Perception (43)

(*Individual experiment*)

Materials: The following figures are to be used.

Method: Draw the illusions of figures 14 *a* and 14 *b* (with the exception of J) in the notebook. They should be made twice the size shown; and should be drawn as they actually are, not as they

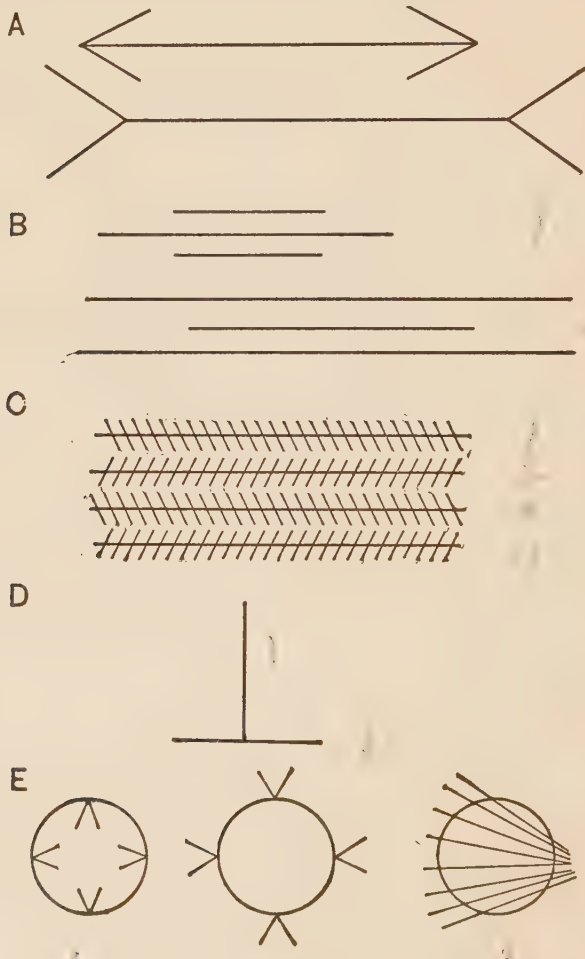


FIG. 14 *a*.

appear. In A the two horizontal lines are of the same length. In B the two middle lines are of the same length. In C the four long lines are parallel. In D the horizontal and vertical lines are of the same length. In E are shown three perfect circles. In F the two figures are exactly square. In G the two diagonals are equal. In H the three slanting segments lie in the same straight line. In I the two circles are equal.

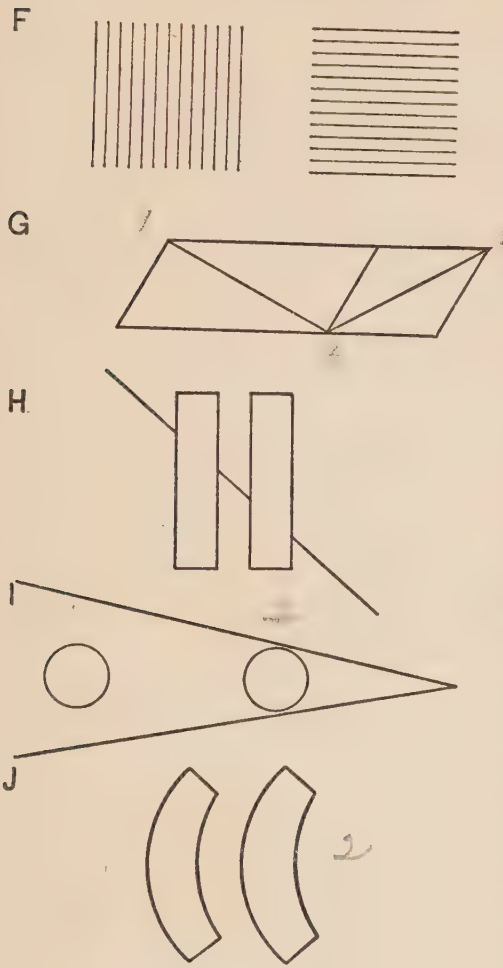


FIG. 14 *b*.

Draw the two equal crescent figures of J, enlarged about five times, on cardboard. Cut the figures out. Observe that the one to the right, when the two are placed in the position shown in figure 14 *b*, seems always the larger. The same is true when the positions are reversed.

Now examine the different illusions in all possible positions and try to ascertain their causes. Make any alterations that may be useful in suggesting an explanation. Try to find ways of looking at the figures in which the illusions can be overcome or eliminated.

Record: Give an explanation of each of

the illusions according to some one of the several theories given in the literature of psychology.[1] Original explanations also should be given whenever possible.

Questions: 1. Draw or describe any other optical illusions with which you are familiar.

*2. Compare the illusions in D and F with a former illusion of horizontal and vertical space perception which you have studied. Can you show that the same cause underlies each?

3. Give five examples of the practical use of illusions in fine arts, interior decoration, stage setting, architecture, dress, etc.

[1] A good discussion of these theories may be found in Titchener: *Experimental Psychology* (Teacher's Manual — Qualitative), pp. 303–28.

C. Three Dimensional Space

1. Stereoscopic Vision (44)

(*Individual experiment*)

Materials: A hand stereoscope; or two cardboard mailing tubes of the same size (approximately 1 inch in diameter and 12 inches long), white translucent paper, and mucilage. Ruler.

Method: A. Analysis.

An object which has three dimensions will cast upon the two retinas slightly dissimilar images. This is because the eyes see the object at slightly different angles. It is the fusion of these two images in the higher nerve centers that gives us our perception of the solid character of the object.

To begin with the simplest condition of three dimensional space, we may take two points, *a* and *b*, whose position in space is such that *b* is to the right of and behind *a*. A diagram, as in figure 15, shows how these points strike the two retinas. The rays may be represented as crossing at *o*. The eyes are focused on point *a*, so that *a*'s image falls on the foveæ of the right and left eyes at a^2 and a^1 respectively. It will be seen that *b* falls nearer to *a* in the left than in the right eye, and that the two images, b^1a^1 and b^2a^2, are consequently dissimilar. It is this dissimilarity as mentioned above which gives us the perception of *b* as back of *a*.

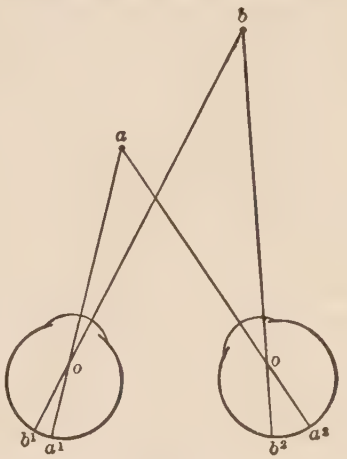


Fig. 15.

In a similar manner we can draw the diagram of three or more points placed in any relative position, keeping in mind that each eye receives its own image of the entire group of points. We can also reverse the procedure and from the two retinal images, b^1a^1 and b^2a^2, locate the two points, *a* and *b*, in space.

Work out the following exercises, keeping a as the focal point.

Problem 1. Draw a diagram, similar to figure 15, but so that b is to the left of and in front of a in space.

Problem 2. With the retinal distance between b^1 and a^1 greater than that between b^2 and a^2, draw a diagram showing the location of points a and b in space.

Problem 3. With the retinal distance b^1a^1 equal to b^2a^2, draw a diagram locating a and b as before.

Problem 4. Draw a diagram showing a bar in the horizontal plane before the eyes, with the left end further away than the right, and with the focus upon the nearer end.

B. Synthesis.

Instead of having the two eyes converge upon a single solid object in space, stereoscopic vision may be obtained by taking the two images as given to the right and left eyes respectively, and after separating artificially the field of vision of the right eye from that of the left, placing them before the right and left eyes. Each eye thus sees only its own image of the object. It is possible to determine these two pictures, called a stereogram, by means of diagrams similar to those you have drawn.

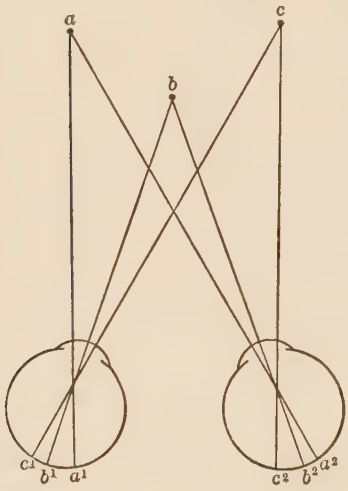


FIG. 16.

Suppose three points a, b, and c, are given, with b between and nearer to the eyes than a and c. The diagram of these three points is shown in figure 16. The stereogram necessary to produce a, b, and c, stereoscopically, when its two pictures are held before their corresponding eyes, is shown in figure 17. It will be seen that the three points have the same spacial relation in the right and left pictures of the stereogram as on the right and left retinas respectively of the diagram, except

that, since the rays cross in the eye, the order of points *a*, *b*, and *c* is in the stereogram the reverse of their order on the retinas.

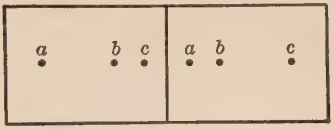


FIG. 17.

Draw diagrams and stereograms according to the following problems. These stereograms are to be verified in the stereoscope. [If stereoscopes are not available, draw the two figures of each stereogram in ink on translucent paper and fasten them with mucilage across the ends of the two mailing tubes. Now look through the tubes toward the light, being careful to hold the right eye's picture before the right eye and the left before the left eye. Alter the distance between the outer ends of the tubes until the figures fuse.] In the conditions of the following problems let the eyes fixate the nearest point of the figures.

Problem 5. A triangular prism standing upright with one edge squarely in front of the two eyes.

Problem 6. A quadrilateral pyramid with the apex pointing directly toward the eyes.

Problem 7. A truncated cone with the smaller base directed squarely toward the eyes.

Record: (1) Present the diagrams and stereograms as called for in the seven problems. (2) State what was seen in the stereoscope (or tubes) in problems 5, 6, and 7.

Questions: 1. By what other method might the stereograms have been produced?

2. What does the diagram in problem 3 indicate in regard to the perception of depth?

3. Why do visitors to art galleries sometimes look at paintings with one eye, through a tube made by the hands?

*4. What is the function of the prisms in the stereoscope?

5. When using the stereoscope (or tubes) did you observe any

other optical phenomena, particularly ones we have already studied?

6. What would be the character of the perception resulting from an interchange of the two pictures of a stereogram?

7. Name several ways in which experience aids us in the visual location of objects.

8. In what other senses beside vision do we have perception of three dimensional space?

XIII. PERCEPTION OF TIME

1. Estimation of Time Intervals (45)

Materials: Watch with second hand.

Method: The experimenter taps with a pencil to mark the beginning and end of an interval of approximately a half minute. The exact length of the interval should not be known by the subject. The subject sits passively attending to this interval. Immediately afterward the subject reproduces the interval as accurately as possible by a tap at the beginning and end of the interval. The error of the reproduced interval (plus or minus) is noted down by the experimenter. This is repeated ten times. The subject should use no deliberate criteria such as counting, but should perceive the time interval directly.

Repeat the entire procedure, using an interval of twice the length of the first. The subject should remain in ignorance of the nature of his error throughout the experiment.

Record: Give the two lists of time estimations with the average error (regardless of signs) and the constant error (regarding signs) for each list.

Questions: 1. Judging from your results what law can you formulate to express the relation of length of interval to accuracy of time perception? Consult also the results of the other members of the class.

2. What effects of practice are seen in your results?

3. Give an account of the subject's introspection of his method of estimating time intervals.

4. Give an explanation of any tendency you may find in the direction of the errors.

2. Perception of Filled and Unfilled Time (46)

Materials: Watch with second hand. Metronome.

Method: The metronome is started at its slowest rate, and the subjects of the class listen passively for a few minutes until they become adjusted to the rhythm of the beats. The instructor then measures a time interval of between 60 and 90 seconds by tapping at its beginning and end. The subject (in each pair of students) listens passively during this interval to the ticking of the metronome. He should not, however, see the instrument nor count its beats. The experimenter (in each pair) carefully times the interval given by the instructor. As soon as the second tap is given the metronome is silenced, and the subject reproduces the interval as accurately as possible, not by tapping, but by a movement of the index finger at the beginning and end of his estimated interval. The error of reproduction (plus or minus) is noted by the experimenter. Ten such trials are made.

The entire procedure is repeated four times, using four other speeds of the metronome, including its highest speed, but keeping the same standard time interval.

Record: Tabulate the five lists (of ten reproduction errors each) for the five speeds of the metronome. Give the average and the constant error for each list.

Questions: 1. Judging from your results what can you say concerning the difference in constant error and in accuracy between filled and unfilled time perceptions?

2. How would you explain these differences?

3. What effect has the variation of the speed of the metronome on the estimation of the filled time interval? How do you account for this effect?

4. State several situations from everyday life in which the perception of filled and unfilled time conforms to the results of your experiment.

3. Perception of Filled and Unfilled Time (Alternative Method) (47) (*Class experiment*)

Materials: Watch with second hand. An interesting short story.

Method: The experimenter measures by tapping an empty time interval of over five minutes. The subjects sit passively with their minds as little occupied as possible, and at the end of the interval estimate its length and note it down. Immediately thereafter the experimenter reads the story for an interval of between three and eight minutes. The subjects give full attention to the story, and at the end of the reading write down their estimations of the length of this interval. The experimenter keeps a record of the two original intervals.

The class makes three such estimations, the original filled and unfilled intervals being varied in the successive trials.

Record: The duration of the three original pairs of intervals is now given, and each subject computes the per cent (plus or minus) of his error for each pair of filled and unfilled intervals.

Tabulate the three percentile errors for the filled, and the three for the unfilled, intervals. Compute the constant error for each form of interval.

Questions: Answer questions 1, 2, and 4 under the preceding experiment.

4. Perception of Subjective Temporal Rhythm (48)
(*Individual experiment*)

Materials: Metronome. Piece of felt.

Method: The metronome is placed in the middle of the back part of the room. It should rest on a piece of felt. The instructor starts the metronome at its slowest speed. The subjects listen passively to the ticking for a minute. They should not look at the metronome nor count the beats. Introspection should be made and note taken of the manner of perceiving the beats, especially in regard to grouping and accentuation.

Repeat the procedure using four other rates of the metronome, including the highest speed, with five minute intervals of rest between the successive rates.

Record: Make a graphic representation of the perception of rhythm for each of the five rates, showing how the sounds were grouped, etc.

Questions: 1. What relation exists between the rate of the metronome and the rhythm perceived?

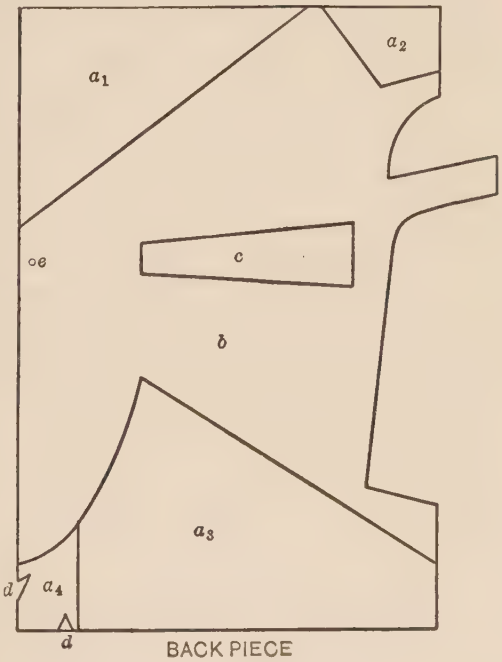
2. From a survey of the results of other subjects state whether there are any general tendencies in the perception of the rhythms of different speeds.

3. Describe from your introspection the sensory processes involved in the perception of rhythm.

4. Give an instance of the perception of subjective rhythm from everyday experience.

Materials: Tachistoscope.[1] If regular tachistoscopes cannot be obtained, they may be constructed from cardboard according to the following directions:

In the construction of the tachistoscope three main parts are involved: a back piece, shown in figure 18; a front piece, shown in figure 19; and a middle piece, or shutter, the back and front views of which are shown in figures 20 and 21. These parts are to be cut with a sharp knife from stiff cardboard (about 8 ply) with a glazed white surface. It is necessary that the parts have the same proportions as shown in the drawings; and they should be made at least double the size shown. The figures may be used as patterns, the measurements as taken from them being always doubled.



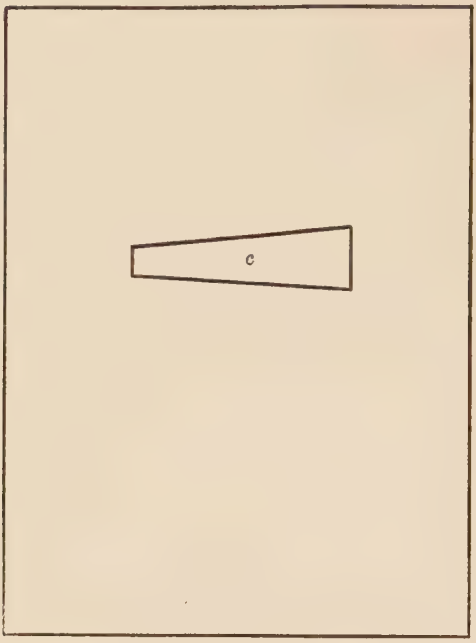
BACK PIECE

FIG. 18.

In the back piece (fig. 18) a_1, a_2, and a_3 are pieces of cardboard of doubled thickness glued securely to the back piece *b*. In a_4, how-

[1] The Dearborn-Langfeld Tachistoscope has been made especially for this purpose and may be obtained from the Harvard Psychological Laboratory. The cardboard form, which is described below, will answer the purpose and can be obtained from C. H. Stoelting Company at a reasonable price.

ever, there is only one thickness of cardboard fastened to the back piece (*b*), the uppermost thickness of a_3 being cut off as shown in the figure; *c* is a window cut in the back piece; *dd* are notches to hold a rubber band; *e* is a small hole to receive a tack which serves as a pivot for the shutter.

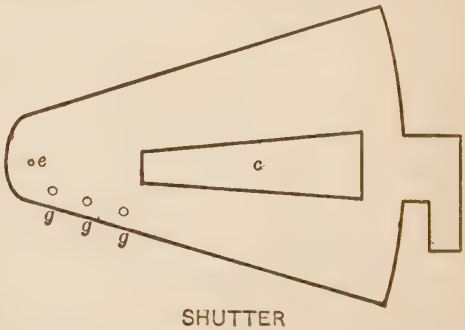


FRONT PIECE

Fig. 19.

The front piece (figure 19) is somewhat wider than the back piece, but has its window (*c*) the same size and the same distance from the top, bottom, and left-hand side as the window in the back piece. It consists of one thickness of cardboard.

The shutter, or middle piece, is shown in figures 20 and 21. The window (*c*) is the same size as in the front and back pieces; and when the shutter is pivoted at *e* to the back piece (fig. 18), its window can be brought into a position exactly coinciding with that of the window of the back piece; *ggg* are three small holes to receive a rubber band. On the reverse side of the



SHUTTER

Fig. 20.

shutter, shown in figure 21, is glued a small piece of cardboard as shown at *h*.

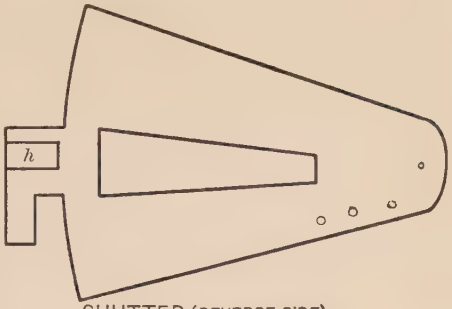


FIG. 21.

The parts are now to be fitted together. The shutter is pivoted onto the back piece at *e*, as shown in figure 22, by a small carpet tack which, on the under side of the back piece, is passed through a cardboard washer and riveted. It should not be fastened too tightly, for the shutter must swing with the least friction possible. Through one of the small holes (*g*) a rubber band is passed and looped through itself as shown, with its other end secured by the notches in the lower left-hand corner of the back piece. A thin and rather yielding rubber band should be selected, but one which is free from flaws. Parts *a* now serve as stops for the shutter, and also give it room to swing freely when the front piece is placed on top.

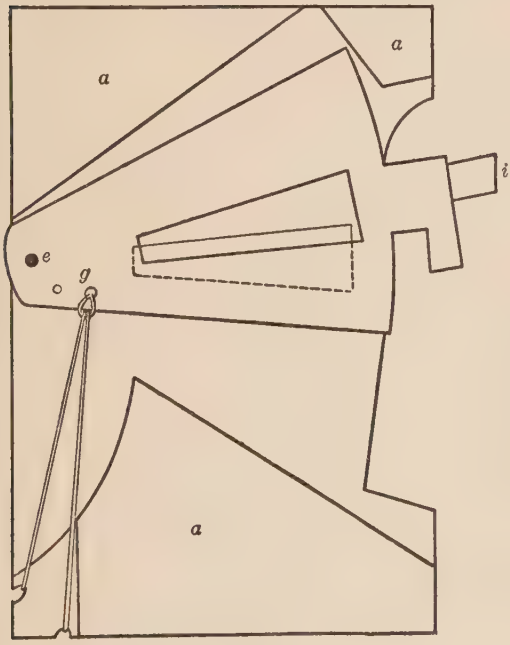
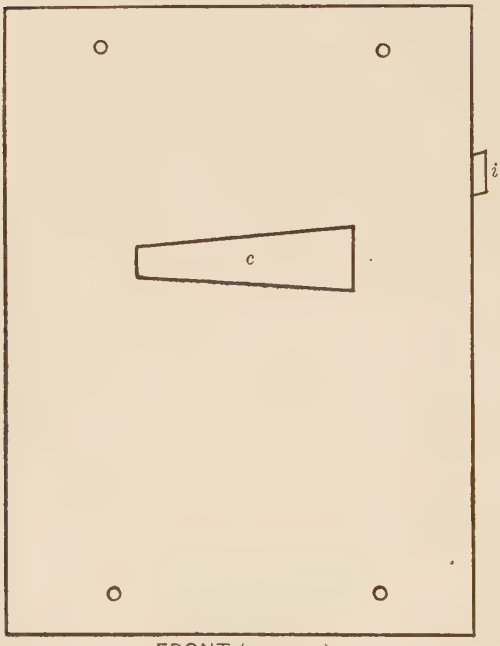


FIG. 22.

Now place the front piece in position over the back piece and shutter as they are shown in figure 22. The left-hand edge of the front piece should coincide with the left-

hand edge of the back piece; and the ' trigger ' (*i*) should project a little to the right of the front piece, as shown in figure 23. The front and back pieces are fastened together by four small brass paper fasteners placed as in figure 23. They are thrust through small slits (not holes) cut through the layers of cardboard with the point of a knife. The essential requirement in fitting the front piece is that the position of its window should coincide with that of the window of the back piece.



FRONT (FINISHED)

FIG. 23.

From the back the tachistoscope appears as shown in figure 24 *A* and *B*. Over the window of the back piece is glued a rectangular piece of cardboard (*j*), as shown in *A*. The glue is applied not in the middle part of *j*, but only at the ends, outside the dotted lines (*k*). This forms a holder through which a slip of paper may be passed and moved up or down across the window of the back piece. At *l* a small aperture is cut which should be at the center of the window of the back piece.

In figure 24 *A* the shutter is 'down.' Its outline is shown by a dotted line. A small hole about the size of a match stick should now be put through the shutter and front piece as shown at f_1 and f_2. They should be so placed that when the window of the shutter is open (i.e., when the shutter is rotated until its window coin-

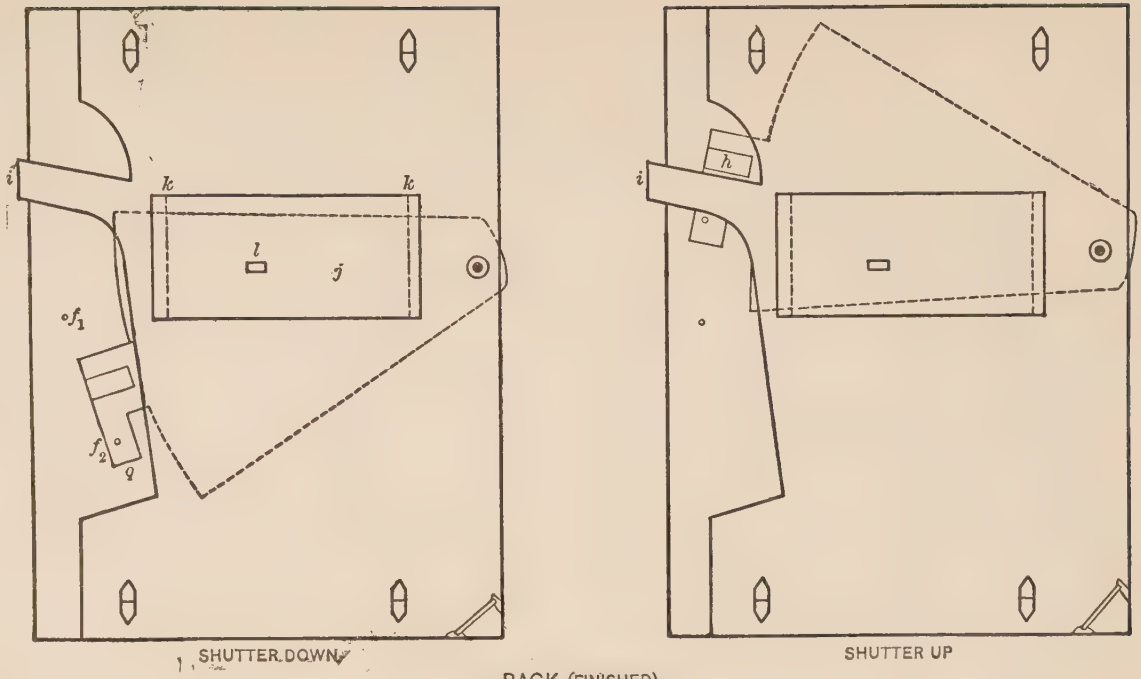


FIG. 24 *A*.

FIG. 24 *B*.

cides with the windows of the front and back pieces), the two holes also will coincide.

Figure 24 *B* shows the shutter 'up,' that is, with the small piece (*h*) caught on the trigger (*i*).

The principle of this tachistoscope is as follows: when the shutter is up, and the tachistoscope 'set,' as in figure 24 *B*, the lower part of the cardboard shutter obstructs the window (*c*) as seen from the front, as in figure 23. The exposure material inserted in the holder (figure 24 *A j*) is therefore concealed. When the trigger (*i*) is bent backward slightly the shutter is released and is pulled quickly by the tension of the rubber band across the coinciding windows of the back and front pieces. As its window crosses this window the stimulus is exposed for a brief interval. For work in perception this interval should be a little less than one tenth of a second. If the movement of the shutter is too rapid or too slow to permit a single act of perception, the rubber band may be either changed or placed in one of the other holes provided near the lower edge of the shutter. The shutter window passes across the opening of back and front pieces closing it again, and is stopped by the piece a_3, shown in figure 18.

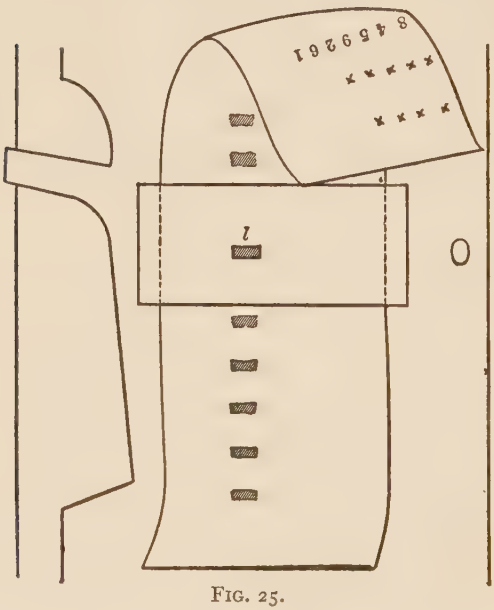


Fig. 25.

The exposure material is printed or written in rows on a strip of paper, and inserted in the holder, as shown in figure 25. On the reverse side of the paper, directly behind each row of stimuli, is placed a

conspicuous mark which appears at the small aperture (*l*) as the slip is pulled through, thus informing the experimenter when the stimulus is in its proper position at the window.

Certain experiments in perception may require a pointer for use in the window. This can be cut from fairly stiff paper, as shown in figure 26. The tip is blackened in order to be conspicu-

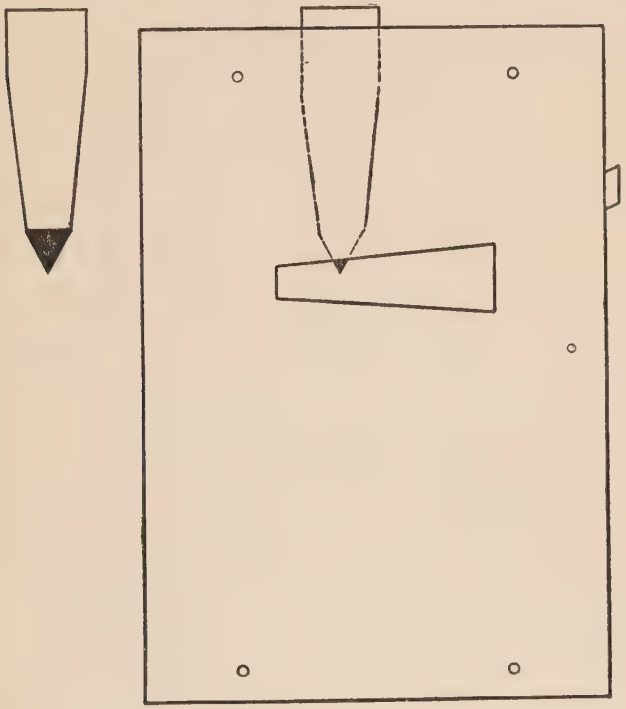


FIG. 26.

ous. The pointer is inserted between the back and front pieces, and can be directed to any part of the window desired.

Work in memory requires an open shutter. This can be provided by placing the two holes (f_1), and (f_2) in figure 24 *A*, so that they coincide, and locking them in this position by a piece of match stick.

A few directions are helpful for the operation of the tachistoscope.

To set the instrument the experimenter holds it in his right hand by the lower right-hand corner, with the back piece toward him. He then places the tip of his left forefinger (having the hand palm up) against the tongue of the shutter (at *q* in figure 24 *A*), and pushes the shutter upward, slipping it under the trigger (*i*). When its cardboard catch comes above the trigger it will spring back, locking the shutter as in figure 24 *B*. The stimulus is then arranged as desired, and the tachistoscope held fairly close to the subject and in good light. To release the shutter the experimenter, still holding the instrument in his right hand *near the bottom*, pulls back slightly the trigger (*i*) with his left forefinger. The tachistoscope must not be held near the middle, for this will prevent the movement of the shutter.

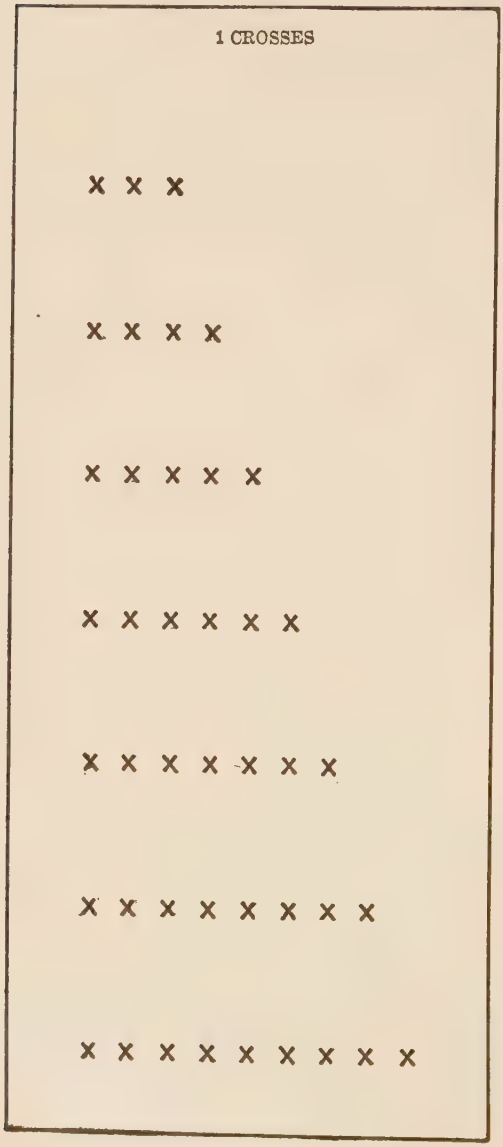


FIG. 27.

Exposure material as described under method.

Method: In order to eliminate all eye move-

ments during the exposure, the tachistoscope should give an exposure of less than one tenth of a second. The subject is seated comfortably, and the tachistoscope placed within reading distance and tilted at a convenient angle. The experimenter inserts the material behind the shutter in such a way that the subject cannot see what is on the paper. This material consists of strips of paper on which are printed by the experimenter rows of visual stimuli of increasing length. Six different kinds of stimuli are to be used as shown in figures 27 and 28. The exact stimuli shown cannot be used except in

2 NUMBERS	3 LETTERS
923	A C X
4782	Z E M R
69453	Y D P S Q
284367	O Y F G I X
9531762	M R L Q E C B
63195842	F S X O G L P K
183746259	B E H N S X P C F

4 FAMILIAR WORDS	5 UNFAMILIAR WORDS	6 SENTENCES
CART	IBEX	GOOD MORNING
HORSE	HYRAX	WHAT IS IT?
SCHOOL	INDIUM	HOW DO YOU DO?
BALANCE	ORILLON	IT IS GOING TO RAIN
FRIENDLY	CANABULA	ETC.
SELECTION	TIMENOGUY	
CONSEQUENT	SQUAMULATE	
INGRATITUDE	GEMMIFEROUS	
CONSTITUTION	PHONOTYPICAL	

FIG. 28.

the case of the crosses. Care must be taken that the subject does not see any of the lists until they are presented in the tachistoscope.

Starting with the top line, which is the smallest series, the experimenter gives a preparatory signal, and after two seconds releases the shutter, exposing the stimulus for less than one tenth of a second. The subject states as accurately and fully as possible what he has perceived. If this is correct the experimenter continues as before, using the successive lines in turn until the subject is unable correctly to repeat the stimulus. Since the first mistake may be accidental, try one or two longer series before finally noting the span of perception for this type of stimulus.

This procedure is carried out for each of the six classes of exposure material.

Record: Tabulate the largest group of units which can be combined into a single act of perception for each of the six types of stimuli.

Questions: 1. Compare the span of perception for the following types of stimuli, and explain the reasons for the differences:

Compare (*a*) crosses and numbers
(*b*) numbers and letters
(*c*) letters and words
(*d*) familiar and unfamiliar words
(*e*) words and sentences.

2. How is the span of perception related to the composition of a good work of art?

3. Why is it necessary to eliminate eye movements during the exposure?

*4. How can an experiment be performed to find how many seconds of time can be combined into a single perception?

XV. PERCEPTION OF WORDS AND MEANING

1. Synthesis of Successive Perceptions (50)

Materials: Tachistoscope as in preceding experiment. Exposure material as described under method.

Method: Five unfamiliar words, considerably longer than the span of perception for unfamiliar words, as determined in the preceding experiment, are prepared for exposure in the tachistoscope. An example of such a word is 'cytoreticulum.' Inasmuch as the subject must not see the word before its exposure, the experimenter must use his judgment as to whether the word is unfamiliar to the subject.

The experimenter presents the first word in the tachistoscope, giving a brief exposure, as in the preceding experiment. The subject notes down the letters he was able to perceive. The exposures are repeated until the subject can grasp all the letters of the word at one time, noting for each exposure the group of letters seen. Repeat this procedure, using the other four words.

Record: Tabulate the successive perceptions of the five words in the form suggested below. The successive perceptions of 'cy-

NO. OF EXPOSURE	WORD		
	1 CYTORETICULUM	2	3 ETC.
1	CYT		
2	CYTORE		
3	L TIC UM		
4	CYTOREL		
5	CYTORE		
6	CULUM		
7	TICULUM		
8	RETICULUM		
9	CYTO		
10	CYTORETICULUM		

toreticulum' are given as an example. This word happened to require ten exposures. Other words of course may require more or less than this number.

Questions: 1. From an examination of your results and from the subject's introspection what general tendencies, if any, would you say the subject shows in synthesizing the successive perceptions of words?

2. How could the words used in this experiment be written so that they could be grasped more readily?

2. Fixation of Attention in Word Perception (51)

Materials: Tachistoscope with a movable pointer to direct attention to definite parts of the exposure window. Five long unfamiliar words selected and prepared as in the preceding experiment.

Method: The experimenter exposes the words in the tachistoscope as in the preceding experiment, repeating until the subject can grasp the entire word. In doing this, however, the following variation from the former experiment is used: For the first exposure the pointer is placed at the middle of the first syllable of the word, for the second exposure it is placed at the middle of the word, and for the third toward the end of the word. The subject notes down his successive perceptions as before. Repeat this procedure, if necessary, until the entire word is seen as a whole.

Record: Tabulate the successive perceptions of the five different words with the various positions of the pointer, as indicated in the table.

NO. OF EXPOSURE	POSITION OF POINTER	WORDS — 1	2	3 ETC.
1	BEGINNING			
2	MIDDLE			
3	END			
4	BEGINNING			
5	MIDDLE			
6	END			
7	BEGINNING			
8	MIDDLE			
9	END			
	ETC.			

Questions: 1. From your results describe the relation of attention to perception.

2. Compare the results of this experiment with those of the preceding, explaining any differences you may find.

3. What does this experiment suggest in regard to aids to perception in advertising? In primary education? In fine arts?

3. Influence of Form (52)

Materials: Tachistoscope. Exposure material as described under method.

Method: The experimenter makes two lists, each containing six three-letter words. One of these lists is composed entirely of words with line letters, the other of words whose first and last letters extend above or below the line. These lists are written instead of printed. Each of the two lists is written in a line, with the words sufficiently small and close together so that all six can be exposed in the window of the tachistoscope at the same time. Figure 29 gives two such lists as examples.

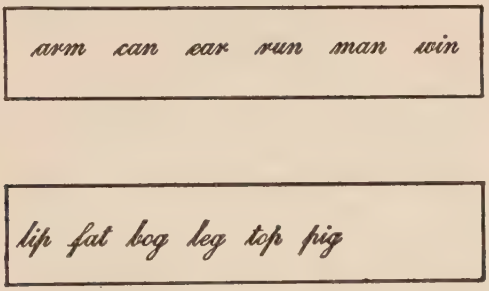


FIG. 29.

The experimenter now presents the row of line-letter words for the usual exposure time and the subject writes down as many of the words as he perceived. The same is done with the other list.

Record: Present the two lists exposed, together with the words perceived by the subject in each.

Questions: 1. If one list is more easily perceived than the other, give an explanation.

2. State practical applications which might be made of the facts disclosed by this experiment.

4. Perceptual Cues (Skeleton Words) (53)

Materials: Tachistoscope. Stop watch or watch with second hand. Lists of skeleton words as described in the method.

Method: The experimenter prepares three lists of skeleton words, formed from familiar five-letter words, using the following scheme of omissions as a model in each list. (Fig. 30.) The lists are written on slips for use in the tachistoscope.

1 — — *a n e*
2 *b* — — *c k*
3 *f l* — — *x*
4 *b r o* — —
5 — *h a i* —
6 *h* — *a* — *e*

FIG. 30.

The corresponding words of figure 30 are plane, block, floor, brown, chair, and house. The experimenter exposes the words, one at a time in the tachistoscope with the shutter left open. The subject forms a word as quickly as possible, substituting letters for the blanks. The experimenter notes the time required for each word. Any sense word the subject may give, which properly fills the blanks, is acceptable. All eighteen words are exposed in this way.

The subject should introspect on his method of perception.

Record: Tabulate as shown below the skeleton words, the words formed by the subject, the time required for each word, and the average time for the six types of omission.

OMISSION TYPES	LIST I			LIST II			LIST III			AVERAGE TIME FOR THE SIX OMISSION TYPES
	SKELETON WORD	WORD GIVEN BY S.	TIME	SKELETON WORD	WORD GIVEN BY S.	TIME	SKELETON WORD	WORD GIVEN BY S.	TIME	
1										
2										
3										
4										
5										
6										

Questions: 1. State and explain the effect of the different forms of perceptual cues, given in the six types of omission, on the time required for perception of the word. In particular, make the following comparisons of omission types:

1 with 4
2 with 3
5 with 6
2 with 5

Note also the value as perceptual cues of letters which extend above or below the line.

2. From the subject's introspection give an account of the manner in which the words were perceived.

5. Determining Tendency (54)

Materials: Tachistoscope. Stop watch or watch with second hand. Exposure material as described under method.

Method: The experimenter prints for exposure in the tachistoscope three lists of seven words each whose letters are transposed. The words in the first list should be unrelated. In the second list they should all belong to the same category; for example, the category in the list given below is that of articles to be found in a schoolroom. The third list should be composed of words all related to one of the leading interests of the subject, such as football, tennis, music, etc. The subject must not know the category of either the second or third list.

The letters of the words should be so transposed that the initial letter of the original word does not come first, nor should any two

I	II	III
A N L I P	E P R A P	E S R O C
E S H U O	H K L C A	T A N B O
B R I N O	U R L R E	E T L F U
L O F O R	H R T C A	H S P R A
I N C A H	E L G B O	S U M C I
S A R G S	N H C E B	N A I O P
T R W E A	A D R O B	R N T O E

FIG. 31.

consecutive letters of the original word retain their relative positions. Figure 31 shows three such lists as examples. In I the words are unrelated; in II they belong to the category of articles in a schoolroom; in III they belong to what might be a personal interest of the subject, — music.[1]

[1] The original words of these three lists are as follows:

I	II	III
plain	paper	score
house	chalk	baton
robin	ruler	flute
floor	chart	sharp
china	globe	music
grass	bench	piano
water	board	tenor

The lists are exposed, one word at a time, with the shutter open. The subject speaks the word, whose transposed letters are given, as soon as he 'sees' it. The time required for the correct perception of each word is noted by the experimenter. A short rest should be given between the lists. The subject introspects on his manner of finding the words.

Record: Tabulate for each list the transposed words, the original words, and the times required by the subject for perceiving the words. Present the average time for each of the three lists.

Questions: 1. Give reasons for any differences you find in the average times of the three lists.

2. Why is this experiment called 'determining tendency'?

3. Give reasons for any extreme variations from the average.

4. Judging from the subject's introspection, do you think the category played a conscious or an unconscious part in perceiving the word?

5. If used as a mental test, what ability or abilities do you think this experiment could measure?

6. What practical application might be made of results obtained by this test?

6. Errors of Perception (Neglect of Misspelling) (55)

Materials: Tachistoscope. Exposure material as described under method.

Method: The experimenter prints a list of twelve words slightly shorter than the threshold span, six of which are slightly misspelled: — for example, STRENGH, BELEIVE, BYCICLE, etc. The misspelling should consist merely of the change of one or two letters; the general form of the word should not be altered.

These words are presented by the experimenter in the tachistoscope. They are given one at a time and for the usual quick exposure interval. After each word the subject writes down what he has seen. He must, of course, not know beforehand which words are misspelled.

Record: Present the two lists (the original and the one produced by the subject) side by side. Underline all cases of oversight of misspelling and any other perceptual errors which may appear.

Questions: 1. Why do we overlook the misspelling of common words?

2. Show how this type of erroneous perception must be taken into account in different occupations.

3. How can it be overcome?

*4. Judging from your own experience, what effect do emotional states have on the accuracy of perception? Give examples.

ATTENTION

XVI. STRENGTH OF ATTENTION (56)

Materials: Stop watch or watch with second hand. The following series of letters and figures which may be used in the manual itself or copied in the notebook, as desired.

(*Münsterberg's Attention Tests*)

Test I

Name:

brloeyeldmpykecatholmpiwrbedxaumtinrtmoxkcrytsoobm

ghdeipysirncedfkjhigyipekvtoeklvneiillzcuyvnewoioupytm

gbhtarsxuefddogmkjiopynlidtopsedfhghotbrdenexerfisaeliey

urfrednjidrwasswygfwcanijkwcryyhwuyoumiofwitlipqhvl

uqlowquwcacekeardfiverwamgoiscexedluratmnkliponmap

mxefghuytlageblyfctiprijseapveruytwomibrylegquieyrcvsa

wtlxtenkrndigerstgtenvluyrcxfurrhy

Test II

Name:

7432568137568374534809645321672836254186281377O5

8164356780692873549062385789327759318208257281 35

9068235763285187372963653645178163209567257076 65

4086185349279058327256309765361856709907658163 56

7903653723850972943582608456670752765902361871 34

5357369273781582367532860953182752802813957753 98

7563260945378296078653461850773182681454638276 12

3546908435472865731

Method: Beginning at the beginning of Test I, the subject underlines as rapidly as possible all groups of consecutive letters which make words, for example 'eye' and 'cat' in the first line. One-letter words, such as 'a,' are not to be underlined. Sometimes more than one word can be formed from a group of letters as s-t-o-n-e, which gives stone, tone, one, and to. The experimenter takes the time required to underline all the words in the series. He should not, however, see the words himself.

In Test II the successive pairs of figures which when added make nine are underlined; for example, 8 1 and 4 5 near the beginning of the first line. The time is taken as before.

The experiment is now repeated with the experimenter and subject interchanged.

Record: Make the following tabulations of the results:

(1) Individual record: State your own time required for each of the tests, and the number of omissions which you made in each. A mistake in underlining should be counted as an omission; and such errors, if made, should not be erased nor rectified.

(2) Group record:[1] For Test I, state the average time required and the average number of omissions for the class.

For Test II, arrange in a table the names of the various members of the class in increasing order of their respective times required for completion of the figure test. Put down the time for each. Find the average, and then in a column to the right, place the deviation of each of the individuals from this average. To do this simply subtract the individual time from the average, or the average from the individual as the case may require, omitting algebraic signs. Find the average of all these individual deviations. This average is called the 'mean variation' (m.v.).

Make another table arranging the members in increasing order of the number of omissions made in the series. Compute the average, the individual deviations, and the mean variation as before.

3rd TABLE

NAMES OF SUBJECTS	PLACE IN 1st TABLE	PLACE IN 2nd TABLE
	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
ETC.	ETC.	

A third table is now made containing the names of the members of the class in increasing order of time required as in the first table, and the numbers indicating their respective positions in the group in regard to omissions, as shown in the second table. This table, as shown in the accompanying figure, presents a direct comparison of the efficiency of the subjects in speed with their efficiency in quality of work. In making the table, if two subjects are tied for the same place, give to each a rank intermediate between the place for which they tie and the next lower place. For

[1] Group records can be most conveniently worked out on the blackboard.

example, if two subjects are tied for third place, give to each $3\frac{1}{2}$ and count the next place to be occupied as 5. If three are tied for third place, rank each as 4 and count the next place 6, —and so on.

Questions: 1. How did your record in Test I compare with the class average?

2. From the results of Test II as shown in the third table, discuss the relation between speed and accuracy in work which requires close attention. The extent to which two such characteristics occur together is known as the degree of correlation. In other words then, does there seem to be a certain correlation between speed and accuracy?

[The degree of correlation may be expressed numerically by using the following formula:

$$r = 1 - \frac{6\Sigma(d^2)}{n\,(n^2 - 1)}$$

Or if fractions occur the following formula may be used:

$$r = 1 - \frac{6\Sigma\,(2d)^2}{4n(n^2 - 1)}$$

where r = degree of correlation

Σ = the sum of

d = difference in rank of the subject in regard to the two traits correlated. That is, if subject A ranks fourth in speed and eighth in accuracy, d would equal 4. $\Sigma(d)$ then is the sum of these differences for the various subjects.

n = number of pairs of measurements.

It is possible for r to range between $+1$ and -1. When $r = 0$, the two traits have no correlation. When $r = 1$, there is perfect correlation; that is, each subject has the same rank under both traits. When $r = -1$, there is perfect inverse correlation; that is, every subject who ranks high in one trait ranks correspondingly low in the other.]

3. Do your results indicate the existence of various types of attention? From a survey of your results and from your introspection characterize the type to which you belong.

4. Do you consider that the omissions were due to fluctuation of attention or to other causes? If the latter, what causes?

5. Of what is the mean variation an index in this experiment?

6. How may this experiment, or the knowledge you have gained from it, be put to practical use in industry?

Materials: A card six inches square on which is drawn a picture in reversible perspective. This picture is that of a cube, as shown in figure 32, which should be drawn almost the size of the card. The letters are to be omitted in the card used. Watch with second hand.

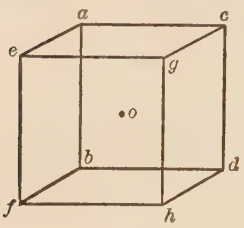


FIG. 32.

Method: The card is placed in a stable, upright position before the subject. The subject fixates the line *ab* and tries to see the cube with the side *abcd* nearer than the side *efgh*. He then fixates *gh* and tries to reverse the figure bringing *efgh* nearer. When he has gained the ability by practice to reverse the figure at will, he is ready to proceed with the experiment.

A. The subject looks at the figure for one minute (time kept by experimenter) with passive attention, allowing his eyes to roam at will over the figure. He tries neither to make nor to inhibit reversals. He counts silently the number of reversals which do occur, and at the end of the minute gives the result to the experimenter. Three such trials are made.

B. Proceed as in method A except that the subject strives to make as many reversals as possible by looking at *ab* and *gh* alternately as in the practice period. The results for three one minute tests are noted as before.

C. Proceed as before except that this time the subject fixates the dot *o* and strives to hold the figure in one position. The number of reversals which occur in spite of his effort is noted in three one minute trials as before. The subject notices any eye movements which may occur, and their relation to the reversals of the figure.

If time permits, repeat the experiment with subject and experi-

menter interchanged. In each of the three methods of looking at the figure a rest of one half minute should be given between the successive trials. Five minutes rest should be allowed between the three methods.

Record: (1) Present a table of the number of reversals for the three different methods, A, B, and C, with the average for each method.

(2) Give a statement, from the subject's introspection of any eye movements or any unusual variations in the appearance of the figure which he observed in method C.

Questions: *1. Explain the phenomenon of reversal as seen in method A.

2. Judging from your introspection how would you say the rapid reversals of method B were obtained?

3. What do you consider the cause or causes of the reversals in method C.

4. State the extremes of ability, that is, the poorest and best records in the class, for the form of attention employed in method B, and also in method C.

5. From a comparison of the three methods and their results, what can you say in regard to the fluctuations of your attention?

MOTOR PROCESSES

XVIII. VOLUNTARY ACTION

1. The Simple Reaction (Motor, Sensory, and Mixed) (58)

(*Class experiment*)

Materials: Chronoscope. Batteries. Telegraph keys. Wiring.

Method: The chronoscope, batteries, and one telegraph key are wired in series so that the release of the key breaks the circuit and starts the clock. Across the binding posts of this key are shunted in series as many keys as there are students. The closing of all these keys closes the circuit and stops the clock. The keys are so spaced in wiring that each student has one in front of him on his table.

A. Sensory Reaction. The experimenter releases the single key which is in direct series with the chronoscope, thus starting the clock. The subject nearest the experimenter presses down his key as soon as he sees the experimenter's finger move. His neighbor presses his key as soon as he is certain that he hears the click of the first subject's key. He is to react to the sound of the key, and should have his attention upon the perception of the signal rather than upon carrying out the movement. He should also have his head turned away from the first subject so that he reacts to the sound of the click, and not to the perception of the movement of the first subject's hand.

The next subject reacts in the same manner, and then the next, and so on until all the subjects have pressed their keys. *Each subject must hold down his key until the last subject has reacted and the clock stops.* The time required for the entire reaction is read from the clock and noted down. Ten trials are made in this manner.

B. Motor Reaction. Proceed as before except that now the subjects' attention is fixed on the act of closing their keys as quickly as possible rather than on the perception of the stimulus.

C. Mixed Reaction. This procedure is the same as the others except that the subjects now assume a less consciously directed attitude, the attention being distributed between the perception of the stimulus and the carrying out of the action.

In all three types of reaction the attitude of the subjects as described above should be maintained throughout the ten trials.

If time permits, the experiment may be repeated using a visual stimulus, viz. the movement of the hand in pressing the key, instead of the sound.

Simplified Method

Materials: Stop watch.

Method: The subjects and experimenter form a chain, each one within touching distance of his neighbor. After a preparatory signal the experimenter touches the right shoulder of the first subject on his left, at the same time starting the stop watch. As soon as that subject feels the tap he taps his left-hand neighbor on the right shoulder. This subject taps the next, and so on until the last subject has been tapped. The watch is stopped as soon as the last touch is made.

The three types of simple reaction are performed as in the preceding method, the stimulus in each type being the feel of the tap, and the reaction the arm movement involved in tapping the next subject. Ten trials are made for each of the three types.

Record: Tabulate the group reaction time for the ten trials under each of the three methods, and compute the average time and the m.v. for each of the three types of simple reaction.

Questions: 1. Which type of reaction was the most rapid? Which the slowest? How do you explain this?

2. Which type gave the greatest m.v.? Which the smallest? Explain.

3. What evidences are there of practice effect?

4. Name five practical activities in which a knowledge of reaction types would prove useful. Show how that knowledge would be of use in each case.

2. The Discrimination Reaction (59)

(*Class experiment*)

Materials: Chronoscope, batteries, etc., wired as in the preceding experiment.

Method: In this experiment the visual stimulus of the movement of the neighbor's hand gives each subject his cue for reaction. The subject places both his hands near his telegraph key and presses the key with the opposite hand from that used by his neighbor, as explained below.

To start the reaction the experimenter presses his key with either the right or the left hand (varying the hand used throughout the ten trials). If the first subject used his right hand, the second will react with his left, and the third with his right, and so on. The time is noted for the complete closing of the circuit. Ten trials are made. The subject should introspect on his 'set' toward the reaction?

Simplified Method

Materials: Stop watch.

Method: The subjects are arranged in a chain, each with his back toward the preceding subject. The experimenter starts the reaction by tapping either the right or the left shoulder of the first subject. If the right shoulder is tapped, this subject taps the left shoulder of the next subject with his left hand. This last subject taps the right shoulder of the third subject with his right hand; and so on until all have reacted and the time has been taken. Ten trials are made, varying the shoulder touched by the experimenter in the successive trials. The subjects introspect on their attitude toward their reactions.

Record: The group reaction times of the ten trials are to be tabulated, and the average and m.v. computed.

Questions: 1. How does the average reaction time compare with that in the various simple reactions? Give an explanation for the difference.

2. How does the m.v. compare? Account for the difference.

3. Are there indications of practice effect? If so, give an explanation, drawing on the introspection of the subjects.

4. There may have been certain individuals in the class who made many mistakes. For what occupations would they be unfitted? Why?

5. Give an introspective account of your attitude in reacting. Note especially cases of inhibition.

*6. What variations in the method can you suggest for this experiment?

ASSOCIATION

XIX. FREE CHAIN ASSOCIATION (60)

Materials: Ruled paper providing space for one hundred words written in columns. Stop watch or watch with second hand.

Method: The experimenter places a common word, such as 'window,' at the top of the prepared sheet of paper. The paper is then placed before the subject who, at a signal from the experimenter, looks at the word and proceeds to write as rapidly as possible all the words that occur to him, the first suggestion being given by the word at the top of the page. No sentences are to be formed. This is continued for three minutes, the time being kept by the experimenter.

The subject, as soon as stopped by the experimenter, underlines all the words which seem to be connected with his personal experience, that is, 'individualistic' or 'ego-centric' associations, such as music — joy; boy — street — accident; etc.

He also marks with a cross all words which seem to have arisen in the mind without any recognizable connection with the preceding words. All the other words in the list might be said to be objectively associated. These associations might have been formed by any of the other members of the class. Examples are cases of rhymes, and such associations as face — hand; barn — door; right — wrong; night — dark; etc.

The subject now writes an introspective account, as far as he can remember, of all that was in mind in forming the associations, paying special attention to conscious suppressions and other intermediate links between the words written.

Record: Present the list of words marked as directed, together with their number, and the introspective account of the subject.

Questions: 1. State the possible reasons for the variation of the

different subjects of the class in the number of words given in three minutes.

2. Give an explanation of the arousal of words which seem to have no associational connection with the words they follow.

3. Judging from the record would you say the subject is of an ego-centric or of an objective type?

4. What practical applications can be made of this experiment?

XX. DETECTION OF SUPPRESSED IDEAS BY THE ASSOCIATION METHOD (61)

(*Class experiment*)

Materials: Chronoscope in circuit with two sound keys, or stop watch.

Method: This experiment studies one of the problems in the application of psychology to the detection of crime. Its object is to find out which of two people is guilty of a certain deed, by means of the analysis of association reaction times and the quality of words associated. The commission of the 'crime' is arranged after the following manner: Two subjects are selected, and are given a sealed envelope containing instructions for the crime. The two subjects leave the room and decide between themselves which is to play the criminal. The 'innocent' subject waits in the hall or in an adjoining room until he is called.

The 'criminal' now opens the envelope and follows the instructions given. It is important that the innocent person should know nothing about the crime, and that no one but the two subjects should know which one is guilty. The crime, which should be arranged beforehand by the experimenter, should preferably be one which arouses a certain degree of 'criminal consciousness.' The following is given as a model for the instruction in the envelope.

" Go into room —, and there you will find in the desk drawer a sealed letter addressed to one of the members of the class. Open it, tearing the envelope as little as possible, and read the contents carefully. Then replace the letter in the envelope and, with the aid of the mucilage you will find on the desk, reseal the flap of the envelope neatly so as to avoid detection. Then put the letter back in its original place in the drawer.

" When you are called into the classroom for the experiment use all your ingenuity to conceal your guilty knowledge of the crime."

In a crime of this sort the letter should reveal some very personal, though fictitious affair of the student to whom it was addressed, such as financial difficulties or a paternal reprimand for debts and extravagance, etc.

After the instructions have been carried out, the 'criminal' joins the 'innocent' subject and awaits summons from the 'court.'

In the meantime the experimenter informs the class of the details of the crime. A list of fifty common words has been prepared beforehand by the experimenter. Of these words twenty-five are closely related to the details of the crime. Such words are called 'crucial words.' The crucial words should be distributed throughout the list, some occurring singly, others in groups of from three to five. A partial list is given below as an illustration, supposing the crime to have been the one described (though actually a totally different crime must be prepared):

chair	disk	church
hat	black	fork
horse	supper	coffee
man	broom	mucilage
dinner	pencil	drawer
keys	letter	money
watch	open	expense
window	debts	etc.
envelope	tree	
telephone	school	

One of the subjects is now called in and seated facing the class. The experimenter speaks the first word of the list distinctly, and the subject replies as quickly as possible with the first word that comes into his mind. If chronoscope and sound keys are used, the words are spoken by each into their respective sound keys, the experimenter thus starting and the subject stopping the chronoscope.

If a stop watch is used the experimenter starts it as he says the stimulus word, and stops it as the subject speaks the reaction word.

The class writes down the stimulus words and the reaction words, with their respective reaction times, as they are given.[1] After the fifty words have been presented to this subject he leaves the room. The other subject is then called in and the list repeated in the same manner to him. The members of the class are not to laugh nor otherwise disturb the subject.

[If time allows repeat the list to the two subjects as before. If a physician's sphygmomanometer (blood pressure apparatus) can be obtained, it will be interesting to compare the blood pressure curves of the guilty and innocent subjects.]

Record: Present the results as shown in the table.

SUBJECT A			STIMULUS WORD	SUBJECT B		
REACTION WORD	TIME	DEVIATION FROM AVG.		REACTION WORD	TIME	DEVIATION FROM AVG.
			ETC.			

The crucial words are underlined, and especially significant reaction times are starred.

Compute and place in your record the average reaction time for the crucial words, the average reaction time for the non-crucial words, and the mean variation for each. Do this for the two subjects separately.

Give also the difference between the average crucial and the average non-crucial reaction times for each subject, and express it as a per cent of the average of the subject's non-crucial reaction times. This is called the 'crucial difference.'

[1] Or these results may be tabulated on the board as the experiment proceeds, and copied by the class.

Next state the difference between the mean variation for the crucial and non-crucial words for each subject.

Finally, write down the name of the person whom you consider guilty, and make a summary of your reasons. The following points are to be considered as possible evidences of guilt:

(1) Greater crucial difference than that of the other subject.
(2) Greater mean variation in reaction time to the crucial than to the non-crucial words.
(3) Occurrence of unusually long reaction time in isolated cases.
(4) Reaction words connected with details of the crime.
(5) Unusual associations.
(6) Misunderstanding of the stimulus word.
(7) Association of nonsense words.
(8) Complete inhibition of reaction word so that no response is given.
(9) Evidence of a plan of reaction pre-arranged by the subject.

The verdict must be based on the entire mass of psychological evidence, and not on one or two criteria alone.

If a reproduction of the list is made, make another table, starring all the reactions to crucial words which differ from the reaction word given in the first test. Find the crucial difference and mean variation difference as before. The reproduction tests may furnish the following further evidences of the subject's guilt:

(1) Greater crucial difference than that of the other subject.
(2) Greater mean variation for crucial than for non-crucial words.
(3) Failure to reproduce the original words given in the first test as reactions to the crucial words.

[If the blood pressure is taken it is probable that the curve of the guilty subject will show greater irregularities than that of the innocent. For example, some experiments have shown that a sense of guilt produces a high blood pressure just before the reaction experiment, which drops gradually during the course of the test.]

Questions: 1. Explain all the phenomena noted under the nine possibilities mentioned above as evidences of guilt.

2. Present a brief account of the guilty subject's introspection regarding his emotional consciousness, and the methods of deceiving the class which he used during his trial. Compare this statement with the objective record obtained.

3. Explain the advantage of presenting some of the crucial words in groups rather than singly.

4. Criticize this experiment as a psychological method of proving the guilt or innocence of a suspected person.

*5. How can this experiment be used in the examination of abnormal states of mind?

MEMORY

XXI. ROTE MEMORY

1. Memory Span for Digits (62)

(*Class experiment*)

Materials: (To be prepared by the experimenter.) Strips of cardboard three inches wide, on which are pasted gummed paper digits about $1\frac{1}{2}$ inches in height. The digits may also be stamped or printed. The cardboard strips are to contain respectively four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, and fifteen digits. The digits are placed in a row on each card, and are so chosen that on a single card no two digits occur in their usual numerical order, nor is any digit repeated until all have been used from 1 to 9.

Four such series of twelve cards each should be made. Two of the series, however (those for methods A and D following) may be merely written on a sheet of paper instead of prepared on cards. The four series should differ in the arrangement of digits in the successive cards or rows.

Method: A. Auditory Perception. The experimenter reads aloud, slowly and distinctly, the four digit row of one of the series written on paper. There should be an interval of one second between the reading of the digits. Immediately thereafter the subjects write down the digits as remembered by them. This is repeated with rows of increasing length until the number of digits is reached which no student is able exactly to reproduce. Each subject continues the test to the end even though he has failed in the reproduction.

B. Visual Perception. The experimenter proceeds as in A except that, instead of reading the rows aloud, he holds the cards up successively before the subjects who read the digits silently. The subjects again write down the rows as they are remembered.

C. Auditory, Visual, and Kinæsthetic Perception. This time the cards are held up and the class reads the digits aloud and in unison.

D. Auditory, Visual, and Motor Perception. The experimenter now reads the other series written on paper as in method A. The subjects write them down as they are being read. Immediately thereafter each subject turns his paper over and writes them down as he remembers them.

A different series is used for each of the four methods. The rows of digits are now reread for each series, and the students examine their work, placing a cross after the row containing the highest number of digits which they reproduced fully and in their correct order in each of the four methods.

Record: Present the series as you have written them down, with the cross marks as directed above.

Questions: 1. Rank your memory spans in the order of their length for the four methods used, and give reasons for the position of the different methods in this rank.

2. From a survey of the records of the class, which form of perception would you consider the most conducive to remembering?

3. State practical applications of the facts disclosed by this experiment.

2. Memory Span for Nonsense and Sense Words (63)

(*Class experiment*)

Materials: (To be prepared by the experimenter.) Seven lists of syllables without meaning, the successive lists having an increasing number of syllables, from four in the first list to ten in the seventh. These syllables are to be composed of three letters each, a vowel between two consonants, and are to be devised according to the following rules. In a single list:

(1) No consecutive syllables should make a sense word.
(2) The same vowel should not occur in two consecutive syllables.
(3) No two consecutive syllables should begin with the same letter.
(4) No two syllables should have two letters identical.
(5) The final letter of one syllable should not be the initial letter of the next.

Eight lists of sense words also are to be made, containing respectively four, five, six, seven, etc., up to twelve words. Each word is to consist of a vowel between two consonants. The words in each list are selected so as to fulfill the five rules given above for nonsense syllables.

Method: The nonsense lists are read aloud by the experimenter, as the digits were read in method A of the preceding experiment, the subjects writing down what they remember after the reading of each list. This is followed after a short rest by a similar presentation of the lists of sense words. The results are checked as before, each student starring the longest sense list and the longest nonsense list which he reproduced without omission. It is not required that the spelling of the nonsense syllables be exact.

Record: Present the lists as you have written them, with those starred which indicate your memory span.

Questions: 1. State numerically your memory span for sense and for nonsense lists, and explain the reason for the difference.

2. Is your variation from the class average in span for sense words approximately the same as your variation in span for nonsense syllables? If not, give reasons for the difference.

XXII. LOGICAL MEMORY

1. Comparison of Rote and Logical Memory (64)

(*Class experiment*)

Materials: Two lists, each containing fifteen monosyllabic sense words, are prepared by the experimenter. In one of the lists the words are unrelated, in the other they are related to some central idea, such as skating, as in the sample lists given below:

ball	ice
tree	pond
house	cold
fox	skate
book	race
fence	edge
sieve	snow
black	smooth
thin	stars
sky	wind
pipe	steel
trip	thin
song	crack
spoon	glide
wire	sharp

Method: The experimenter reads the unrelated list distinctly, at the rate of one word per second. The subjects immediately thereafter write down as many of the words as they can remember, regardless of order. This is repeated, using the related words.

Record: Present the two lists as remembered by you.

Questions: 1. Give reasons for the difference in the length of the two lists remembered, and describe what went on in your consciousness during the hearing and the recalling of the words.

2. State and account for the probable effect of reading the lists at a more rapid rate.

3. Explain the practical importance of the individual differences you may find in the class in regard to the comparative grasp of related and unrelated words.

2. Reproduction of Connected Ideas (65)

(*Class experiment*)

Materials: A literary description of about one hundred words, and containing a large number of concrete details, is selected by the experimenter. He indicates the distinct ideas by underlining each concrete object and each distinct word or phrase which qualifies an object, as in the following example:

The day is steeped in the haze of summer merging into autumn; a distinct bloom of atmosphere, like the ruddy tints of a peach, settles over hill and valley, mingled with the rich yellow hues of dust and golden sunshine, while innumerable purple clusters of ripening grapes glimmer richly amidst the shriveled leaves of the vineyards. A fair land extends beyond the opening valleys with the city and sea sparkling below. In season, chestnut, oak, and willow trees have budded; and in the spring, almond, peach, and cherry have bloomed in clouds of rosy and snowy blossoms.

Method: The experimenter reads the description slowly and distinctly. The class listens attentively and at the end of the reading each subject writes as exact a reproduction of it as he can. When they have finished, the description is re-read and the various ideas indicated by pauses in the reading. The subjects underline the ideas which they have reproduced in their descriptions. Ideas are underlined which are given either in the original words, or in words equivalent in meaning. It is not required that the details be reproduced in their exact original order.

Record: Present the reproduced description, underlined as described, and give the number of separately underlined ideas.

Questions: 1. From a comparison of your results with the class averages, do you rank higher in the class in your rote memory or in your logical memory?

2. Compare the mental factors involved in this experiment with those involved in hearing and recalling the second list of the preceding experiment.

3. What parts of the description were best remembered? Why?

XXIII. MEMORY AND THE LEARNING PROCESS

1. Effect of Length of Series on Learning and Retention (66)

Materials: Tachistoscope with shutter open. If this has not been obtained or made, a piece of cardboard 5 x 8 inches, with a slit 2 inches long and one half inch wide, can be used. Metronome.

Four lists of three-letter nonsense syllables are made by the experimenter, following in the construction of each list the rules given under the second experiment in rote memory. Two of these lists are to be of eight syllables, and two of fourteen. The same syllable must not occur twice throughout the entire four lists; and it is well to have the lists as dissimilar as possible. The experimenter prints the lists on strips of paper in the usual way for use in the tachistoscope. It is important that the subject does not see any of the syllables until they are presented.

Method: A. Learning. The experimenter places an eight-syllable list in the tachistoscope (or behind the window of the cardboard) in such a way that the first syllable only is exposed. The metronome is set for the class at 60, and the experimenter pulls the list gradually across the opening, exposing one syllable at every second click of the metronome. If a metronome is not available, he may use an estimated interval of two seconds between syllables.

As each syllable comes into view the subject reads it in a very low voice, until all have been exposed. The list is then repeated and the subject reads as before. He should, however, try as far as he is able to recall each syllable before its appearance at the window. The list is repeated in this manner until learned, that is, until the subject can recall in the same repetition every syllable correctly before its appearance.

The number of repetitions required, not including the first one correctly anticipating the list, is noted by the experimenter. The experiment is repeated for the other lists, learning first one of the

fourteen-syllable lists, then the other fourteen, and finally the other eight-syllable list.

B. Retention. (Saving Method.) After the experiment described above, the lists should be kept by the experimenter, and the subject should neither see them nor think of the syllables. At the next meeting of the course the subject relearns the lists in the same order, and in the same manner as before. The number of required repetitions is noted.

Record: Present the nonsense lists used. For A give the average number of repetitions required for the two eight-syllable lists, and the average for the two fourteen lists. Express the ratio of these averages to the number of syllables in the lists respectively.

For B find the average saving of repetitions in relearning the eight-syllable lists, and the average saving in the fourteen-syllable lists. Express these savings as per cents of the average number of repetitions required in the original learning of the lists respectively.

Questions: 1. Discuss your results under A, giving reasons for the difference in the ratios obtained.

2. Did practice have any effect on the learning of the lists? If so, what? Is there also practice effect shown in the relearning?

3. In your results under B, if the percentages differ, give reasons for the difference. Do you think overlearning might have played a part here? If so, how?

4. Why were nonsense syllables used in this experiment?

*5. What other methods of investigating memory with nonsense syllables are used in experimental psychology?

2. Unconscious Associations (67)

Materials: Exposure apparatus as in the preceding experiment. Two lists of fourteen, three-letter nonsense syllables devised as before.

Method: The subject learns the two lists as in method A of the preceding experiment. The number of repetitions required is noted.

The experimenter now rearranges these syllables, forming two other lists as follows: The first list should contain the first, third, fifth, seventh, ninth, eleventh, and thirteenth syllables of each original list. The second should contain the second, fourth, sixth, eighth, tenth, twelfth and fourteenth of each original list. For example, if the two original lists are respectively I_1 I_2 I_3 I_4 I_5 etc. and II_1 II_2 II_3 II_4 II_5 etc., the derived lists will be as follows:

List A. I_1 I_3 I_5 I_7 I_9 I_{11} I_{13} II_1 II_3 II_5 II_7 II_9 II_{11} II_{13}

List B. I_2 I_4 I_6 I_8 I_{10} I_{12} I_{14} II_2 II_4 II_6 II_8 II_{10} II_{12} II_{14}

List A is now learned by the subject in the usual manner, and the number of repetitions noted.

It is possible that in this learning the intermediate syllables, I_2 I_4 etc., as learned in the original list, were unconsciously 'stirred up.' To prove this the subject now learns list B which is composed of these intermediate syllables, in order to find whether this requires fewer repetitions than A. In other words, this will show whether while learning list A he has been unconsciously strengthening the memory of list B.

Record: Present the four lists with the number of repetitions required for each.

Questions: 1. What is meant by 'remote association,' and how may it have played a part in this experiment?

2. What other factor may have aided in making it possible to learn B with fewer repetitions than A?

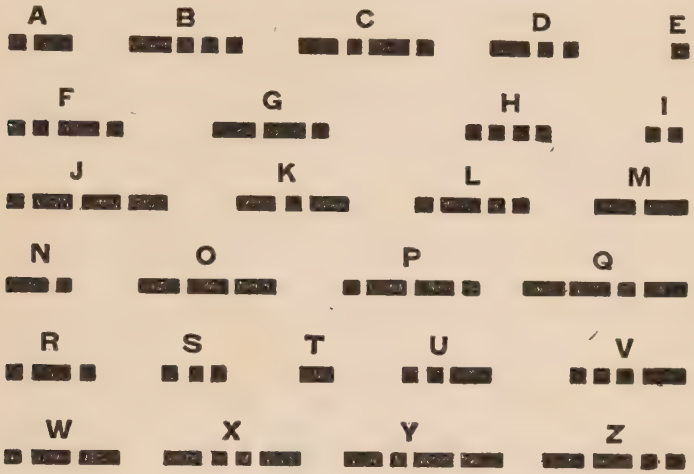
*3. What method might be used to test the memory value for syllables intrinsically, that is individually and apart from associational connection?

4. Describe a method for testing the memory value of various degrees of remote associations.

3. The Learning Curve (68)

(*To be done individually out of class*)

Materials: The Continental (Wireless) Telegraph Code as given below.



Method: The members of the class are to study the process of learning by translating into the wireless code a given text for definite periods each day throughout two weeks. A text should be chosen from any book accessible to the whole class. In translating, instead of making, for example, a short and a long dash, make a short perpendicular line and a long dash. Thus C would be written — | — | By using short perpendicular marks instead of short dashes confusion of long and short dashes is avoided.

One half of the class should work ten minutes in the morning of each day; the other half five minutes in the morning and five minutes in the afternoon of each day. Work always at your highest speed in order to make as good a record as possible. Be careful to leave a space between the different groups of dots and dashes representing letters. After each period of work count and note the number of letters translated. Put down also the date and hour of working.

Record: Present the results in the form of a curve, the horizontal axis indicating the successive days, and the vertical axis the number of letters translated.

The group of subjects who work twice daily should plot two curves, one for morning and the other for afternoon work. These curves should be plotted on the same axes, the one in red, the other in black. Figure 33 is an example of two such curves. Since you will doubtless translate more than fifty letters in the first five minutes, it will be well to start with 50 as the first point on the vertical axis. The succeeding points may be arranged in steps of five.

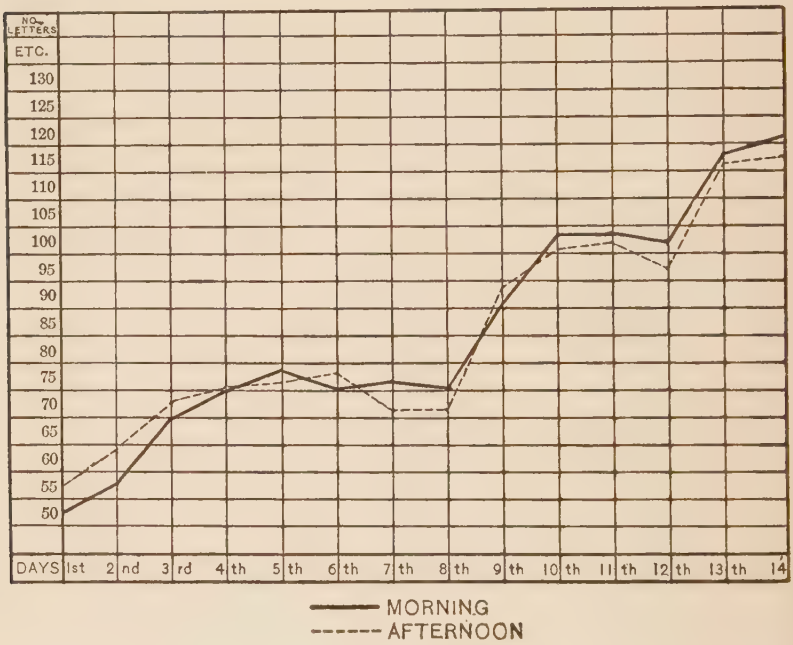


Fig. 33.

Questions: 1. Give an explanation of the variations in the ascent of your learning curve, together with an introspective account of your method of learning and applying the code.

Curves showing the learning process in typewriting, etc., have

contained 'plateaus,' that is, intervals during which there was no progress. These periods are generally followed by a decided rise. If such plateaus occur in your curve, include these in your explanation.

2. Those students who have worked twice daily are to compare the ascent of their morning and afternoon curves, and to state which half of the day they consider most favorable for memorizing. They are to discuss also the various factors which may account for the differences in the curves.

3. From a comparison of the class record of attainment of those who worked twice daily with the attainment of those who worked only once daily, what can you suggest in regard to the most efficacious methods of learning in general?

XXIV. RECOGNITION AND DISCRIMINATION IN MEMORY

1. Recognition (69)

Materials: Watch with second hand. Twenty lists of ten dissyllabic words each are prepared by the experimenter. Each list is written very plainly on a separate slip of paper, and the lists are to be arranged in ten pairs, A_1 A_2, B_1 B_2, etc., according to the following scheme: The second list of each pair is to have one word identical, except for one letter, with the word which occupies the same position in the first list. The other nine words of the second list are to be entirely different from those of the first. An example

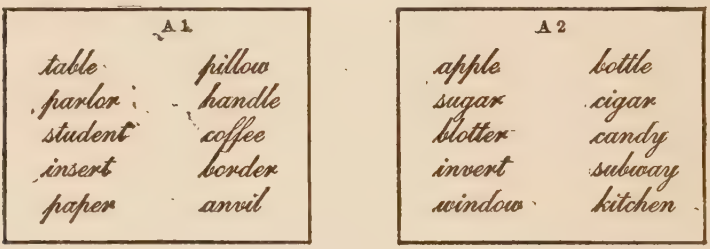


FIG. 34.

of one of the ten pairs of lists, showing the arrangement of the words, is given in figure 34. The fourth word in the first row presents the similarity mentioned.

All ten pairs of lists are made in this manner, except that the position of the similar word is changed in each pair, using each of the ten positions. Further examples of such similar words are: *retort, report; wander, wonder; shiver, shaver;* etc.

Method: The experimenter places the first member of one of the pairs of lists, covered with a paper, on the table before the subject. After a preparatory signal, 'now,' he removes the paper and allows the subject to scrutinize the list for six seconds. The second

list is then exposed in like manner for six seconds. The subject examines this second list trying to find the word which is similar to a word in the first list. If he succeeds, he names this word and also, if possible, the corresponding word in the first list. These words are noted down by the experimenter.

The procedure is repeated using the other nine pairs of lists, allowing a short rest between pairs.

Record: Present the words of the second lists which the subject recognized as similar to words in the respective first lists, and opposite each the word of the first list if it was correctly recalled. Indicate also the position in its list of each of the similar words recognized.

Questions: 1. It has been asserted that in order to recognize similarity and difference we must have both the objects in mind for comparison. Criticize this statement from your results, and state what various degrees of completeness in the recognition of likeness and difference are possible.

2. Give examples from everyday life of these different degrees of recognition.

3. What positions seem especially to favor recognition? What practical applications can be made of this fact?

2. Discrimination (70)

Materials: Watch with second hand. Ten pairs of lists of ten dissyllabic words each are prepared by the experimenter. They are written on slips of paper as in the preceding experiment. This time, however, the second list of each pair is identical with the first list, except for one word which is altered by changing one letter. The position of the altered word should be different in each pair of lists.

Method: The method is the same as that in the preceding experiment, except that this time the subject is to look in the second list for the word which has been changed, and is to try to discover what the change is. The experimenter notes the results as before.

Record: As in the preceding experiment present the words discriminated by the subject, with the original word in each case if correctly recalled, and their positions in the lists.

Questions: 1. From the results of these last two experiments state whether you find it easier to recall a similarity when the surroundings are different, or to discriminate a difference when the surroundings are identical.

*2. What other attitude might the subject take toward the lists in this experiment?

3. From the introspection and results in this experiment what can you offer further in regard to the statement made in the first question of the preceding experiment?

IMAGERY

XXV. KINDS AND VIVIDNESS OF IMAGERY (71)

(*Individual experiment*)

Method: The purpose of this experiment is to ascertain whether you can call to mind various sensory experiences of the different senses, and if so, in what terms (visual, auditory, kinæsthetic, etc.) and how vividly. These reproduced sensory experiences of the various senses are called 'centrally aroused sensations,' or 'imagery.'

Sit quietly and try to imagine the following experiences. Grade the vividness of each image on a scale ranging from one (a very dim or weak image) to five (an image as vivid as in actual perception). In the first group try to have your imagery purely in visual terms, for in this group only the visual imagery is to be graded. In the second group try to produce purely auditory imagery, and grade for the auditory form; and so on.

(1) Visual
   (a) A five-cent piece.
   (b) A street car.
   (c) Your bedroom as you enter.
   (d) Your study as seen from the hall doorway.

(2) Auditory
   (a) The sound of an automobile horn.
   (b) The bark of a dog.
   (c) The sound of your own name.
   (d) A familiar melody.

(3) Olfactory
   (a) The smell of coffee.
   (b) Of freshly cut grass.
   (c) Of fresh paint.
   (d) Of old books.

(4) Gustatory

(a) The taste of lemon.
(b) Of sugar.
(c) Of salt.
(d) Of orange peeling.

(5) Tactual

(a) The feeling of smooth glass.
(b) Of sandpaper.
(c) Of silk.
(d) Of wool.

(6) Kinæsthetic

(a) The movement sensations of shaking hands.
(b) Of climbing stairs.
(c) Of rowing a boat.
(d) Of dancing.

(7) Thermal

(a) The sensation of cold water on the face.
(b) Of a hot bath.
(c) Of a hot potato.
(d) Of ice water in your mouth.

(8) Pain

(a) The prick of a pin.
(b) A burn.
(c) A pinch.
(d) A scratch.

Record: (1) Present a table of the various sensory experiences given above, placing after each its numerical rank. Give the average rank for each of the eight sensory forms.

(2) Make a list of the eight senses given above, arranged in decreasing order of the vividness of their respective imagery.

Questions: 1. Do the results of your experiments in memory and association give similar evidence to support your ranking of the various forms of imagery?

2. How might you make practical use of your results in this experiment?

3. If in the free chain association experiment you were to find a predominance of verbs, what explanation could you give?

4. How do you account for any differences in grading which you may find among the four images under any one sensory form?

*5. Of which form of imagery have you better command, auditory or visual? Test this by finding how many distinct and unrelated images you can form in one half minute for each of these two sensory types.

(*Individual experiment*)

Method: Each subject is to solve mentally the following problem, paying attention to the kind of imagery he uses.

Imagine a three-inch cube painted green on all sides. Suppose this cube were to be cut into small cubes of one inch each. Imagine how this division of the cube would be made. How many of the small cubes now formed have paint on three sides; how many on two sides; how many on one; and how many not at all?

Record: Give your solution and an introspective account of the imagery involved in solving the problem.

Questions: 1. From a survey of the class records, into what imaginal types would you say the individuals may be grouped? Which type predominates, and which type gave the most correct answers?

2. How many of the class could not solve the problem? How do you account for their failure?

3. Name three practical situations in which you would use the same kind of imagery as in this experiment.

XXVII. IMAGERY AND VOLUNTARY SUPPRESSION (73)

Method: The subject is to count aloud up to twenty-five, omitting five numbers which are to be previously designated by the experimenter. For example, the experimenter says: " Count from one to twenty-five, omitting four, nine, twelve, seventeen, and twenty-three." The subject follows the instructions, counting in a low voice, and introspecting on all the imagery involved. For this purpose he divides the introspection into three periods, — that for the fore period, the main period, and the after period. The fore period is that immediately following the instruction, and in which he becomes ' set ' for the task; the main period is the actual counting; the after period is that immediately following the counting.

In the fore period the subject pays attention to the form in which he holds the instruction in mind, and to the manner in which he prepares to perform the task. In the main period he observes whether the numbers to be inhibited come to consciousness, and if so, in what form. In the after period he notes any imagery involved in his consciousness of the success or failure of the task. The experimenter notes down the introspection as given by the subject.

The experiment is now repeated using the letters of the alphabet, omitting five letters as directed by the experimenter. Introspection is obtained as in the preceding task.

Repeat the experiment again having the subject count backward from twenty-five, omitting five numbers which should be different from those omitted in the first exercise.

Record: (1) Present the three series with numbers and letters omitted, indicating any failures that may have occurred.

(2) For each of the three tasks, give the three introspective

accounts (for fore period, main period, and after period), as reported by the subject.

Questions: (1) From a study of your results discuss the functional value of imagery in the voluntary suppression of ideas.

(2) Describe the imagery involved in a muscular act of 'will,' such as throwing a ball at a mark.

AFFECTION

XXVIII. METHOD OF IMPRESSION

1. Comparative Affective Value of Single Colors (74)

Materials: Ten one-inch squares of paper of the following colors: (fully saturated) red, orange, yellow, green, blue, purple; (unsaturated) pink, light green, light blue, light violet.

A piece of neutral gray cardboard six inches square in which are cut two windows three quarters of an inch square, placed side by side about one inch apart.

Method: The purpose of this experiment is to find the order of preference for a series of colors. To do this the subject must compare separately each color with every other color. The experimenter places the red square behind the left window of the cardboard which rests flat on the table. He places an orange square behind the right window. When he signals 'ready' the subject looks at the two colors and decides which is the more pleasant. The experimenter notes this preference by making a mark opposite the name of the preferred color in a table of all the colors.

Red is then compared in the same way with each of the other colors, and the preferences noted as before. The subject rests with closed eyes between the comparisons.

Orange is now compared in the same manner with every other color except red; yellow is compared with every other color except red and orange; and so on until all possible comparisons have been made. This is known as the method of 'paired comparison.'

The entire experiment is now repeated, the experimenter this time placing the standard color always behind the right window, and the comparison color behind the left. By reversing the positions of standard and comparison colors which obtained in the first procedure we thus offset the space error, — that is, the tend-

ency to judge the color to the right (or to the left) always as the more pleasant. The marks for preferences are placed in the same table as in the first procedure.

The subject introspects throughout the experiment upon the factors which influence his judgments of preference.

Record: A. Individual. Present the table with the marks indicating color preferences in the two methods of presentation. Count the number of marks for each color, and place the numbers in their proper places in the table. Paste the colors in the notebook in order of preference as indicated by the respective preference totals. [If the subject uses the colors for his notebook, the experimenter may simply write the names of the colors in the preference order.]

B. Class. The order of preference of the colors for the class as a whole is to be worked out and presented in the following tabular form.[1] The first perpendicular column gives the ranking by the

COLOR	NAMES OF SUBJECTS						SUM
	SUBJ. A	SUBJ. B	SUBJ. C	SUBJ. D	SUBJ. E	ETC.	
RED	4	2	8	3			
ORANGE	1	1	3	9			
YELLOW	6	9	6	4			
GREEN	3	5	2	ETC.			
BLUE	8	7	ETC.				
PURPLE	10	4					
PINK	5	10					
LIGHT GREEN	7	3					
LIGHT BLUE	9	8					
LIGHT VIOLET	2	6					

first subject of the various colors. Further, from the horizontal columns it can be seen that red received fourth place in preference from subject A, second place from subject B, eighth from C, third

[1] The simplest method is to place the table on the blackboard and have each experimenter read the order of preference obtained from his subject.

from D, etc. Orange received first place from both A and B, third place from C, ninth from D, and so on. It is evident that the smaller the sum given at the left of the table for any color, the higher that color stands in the order of class preference.

The names of the colors are now listed in the order of preference, the first color being that which received the smallest sum, the last being that which received the largest sum.

Questions: 1. From the results, individual and class, state the relation which exists between the affective value of colors and —

(*a*) their hue;

(*b*) their degree of saturation;

(*c*) their degree of brightness.

2. From the subject's introspection state the subjective factors which influence preference, such as —

(*a*) ' dirty ' appearance of colors;

(*b*) ' coldness ' or ' warmth ';

(*c*) associations, such as dark green calling up a pleasant trip on water, etc.;

(*d*) personal characteristics suggested by the color, such as jealousy, innocence, dignity, etc.

3. From the subject's introspection give also an account of physiological states which may have been produced by the affective reaction. Examples of such states are quickened pulse, altered respiration, empathic movements, etc.

4. You have arranged the colors in the order of your preference. Is the series as a whole the most pleasing arrangement possible? Discuss this.

5. As far as possible account for the differences you find between your order of preference and that of the class.

2. Comparative Affective Value of Color Combinations (75)

Materials: Five one-inch squares of each of the following colors: (saturated) red, yellow, green, blue; (unsaturated) light pink, light blue. Two cards with windows, similar to the card used in the preceding experiment.

Method: The experimenter lays out the colors in pairs, in a convenient place out of the subject's sight, making all possible combinations, each pair consisting of two different colors. There will be fifteen pairs. Write the names or initials of the colors as combined in the respective pairs in a table. For example:

R Y
R G
R B
etc.

The experimenter places the two cardboards side by side on the table, putting one pair of colors beneath the windows of the right-hand card, and another pair beneath the windows of the left. Each color pair is to be compared with every other color pair in the same manner as the single colors were compared, and the preferences noted in each comparison by a mark in the table.

If time is limited, this experiment need not be repeated with changed relative positions of the standard and comparison pairs, as was done previously with single colors to eliminate space error.

Record: (1) Present the table of the subject's preferences, with the number of marks for each pair counted and recorded.

(2) The color combinations are pasted in the notebook in the order of the subject's preference.

Questions: 1. Can you show from your results that the affective value of color combinations is dependent on the relative hues of the colors combined? On the relative brightness? On the relative saturation? If so, what laws can you formulate to cover these points?

2. Does your preference for single colors appear to affect your preferences in the combinations? If so, how?

3. From introspection give reasons for some of your color preferences.

Note: If time permits, further comparative affective values may be studied, using series of odors, or of tastes, or a series of tactual stimuli consisting of sample textures such as wool, sandpaper, tin, silk, etc., glued to the bottoms of small boxes.

3. Affective Value of the Relative Position of Colors [Apparent Heaviness of Colors] (76)

(*Individual experiment*)

Materials: Colored papers: red, green, dark blue, yellow.

Method: Cut out four triangles $1\frac{1}{2}$ inches high, each formed of two colors in the proportions shown in figure 35. In the four triangles the colors are as follows:

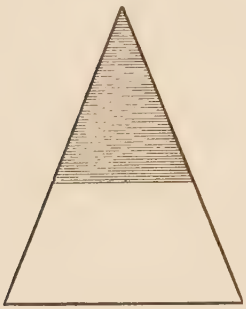


FIG. 35.

Triangle no. 1. Lower half yellow, upper half blue.

Triangle no. 2. Lower half blue, upper half yellow.

Triangle no. 3. Lower half green, upper half red.

Triangle no. 4. Lower half red, upper half green.

In each triangle the altitudes of the upper and lower sections are $\frac{7}{8}$ and $\frac{5}{8}$ inch respectively.

Paste the triangles in the notebook, (1) and (2) side by side, and (3) and (4) side by side. Hold them up vertically before you and judge which arrangement is the more pleasing in each of the two pairs.

If time permits repeat the experiment using other pairs of figures as shown in figure 36. Try to account for the presence or the absence of the phenomenon in each pair.

FIG. 36.

Record: Indicate your preference in the notebook for each pair of triangles, and state which pair offered the greatest difference in affective value between its two triangles.

Questions: 1. From your results formulate a law covering the phenomenon of apparent heaviness of colors.

2. From your introspection state the reason for your preference in each pair.

3. What applications can be made of this phenomenon?

4. Does the affective value change with associative interpretations of the figures? Test this by imagining that one of the squares shown in figure 36 represents a window with the shade halfway down, or the horizon at sea, etc.

5. Do you think that this phenomenon depends on the relative brightness, relative saturation, or relative hues of the colors?

4. Comparative Affective Value of Linear Proportions (77)

Materials: A set of six cards, each 12 × 2 inches, is prepared as follows by the experimenter. Each card contains a line $9\frac{3}{16}$ inches long, and each of these lines is divided into two parts. The division occurs at a different point on each card. A sample of one of

FIG. 37.

these cards is shown (reduced size) in figure 37. The six lines are to be divided as follows:

Card 1. Bisection.

Card 2. The division mark two thirds of the distance from the left end.

Card 3. The division mark three quarters of the distance from the left end.

Card 4. The division mark $6\frac{1}{16}$ inches from the left end.

Card 5. The division mark one quarter of an inch to the left of that in card 4.

Card 6. The division mark one quarter of an inch to the right of that in card 4.

The division of card 4 represents approximately the Golden Section. That is, the smaller part is to the larger as the larger is to the whole line. The actual proportion here is $3\frac{3}{4}:6\frac{1}{16} = 6\frac{1}{16}:9\frac{3}{16}$.

The cards are lettered from (*a*) to (*f*), but not in the order here given, for the subject must not know which proportions are designated by the different letters.

Method: The six different divisions of the same line are to be arranged by the subject in order of preference, using the method of paired comparison. The experimenter presents each card in turn with every other card, and the subject indicates his preference as in the experiment with colors. The preferences are noted by marks in a table containing the letters of the cards.

Record: A. Individual. Present the table containing the preference marks and their sum for each line division. Give also the arrangement of the six cards in order of the subject's preference (from the table), stating in the case of each card what proportions the division represents.

B. Class. The results of the class's first and second choices are to be arranged in the following tabular form. As each of the divisions is called, the subjects indicate by a show of hands how many gave it the first, and how many the second position. In this table the cards are numbered as they are under 'materials.'

CARD NO.	DIVISION	NO. SUBJECTS 1st CHOICE	NO. SUBJECTS 2nd CHOICE	SUM OF 1st AND 2nd CHOICES
1	BISECTION			
2	TWO THIRDS			
3	THREE FOURTHS			
4	GOLDEN SECTION			
5	¼" TO LEFT OF G. S.			
6	¼" TO RIGHT OF G. S.			

Questions: 1. What were the subject's first and second choices? Give the subject's explanation of why they were chosen.

2. Discuss the results of the class.

*3. If the golden section was found pleasing, did the parts of the line seem to balance? If so, what were the subjective factors involved?

4. Describe briefly three particular works of art in which the golden section (approximately) is employed in the arrangement of figures, lines, and objects.

XXIX. METHOD OF EXPRESSION

1. Feeling Tone and Motor Activity (78)

Materials: A metric rule. Unruled paper.

Method: The subject brings to mind a rather strong emotional situation, preferably one he has experienced. This emotional state must have a decidedly pleasant feeling tone. Still thinking of this pleasant situation he draws free-hand a horizontal line of any length on the unruled paper. The experimenter then removes the paper and gives the subject a similar sheet on which he draws a line which seems to him to be of the same length as the first line. This time, however, he thinks of an emotional situation which has a decidedly unpleasant feeling tone.

Now the subject thinks first of an unpleasant situation and draws a line as before. The same unpleasant situation as was employed in the first pair of lines may be used, provided it does not lose its emotional strength by repetition. He then reproduces this line, thinking of a pleasant situation which also may be the same as that used in the first trial unless it has lost its strength.

Ten such pairs of lines are drawn, with short rests between pairs. They should be alternated so that if in the one pair the 'unpleasant' line comes first, in the next pair the 'pleasant' line is the one first drawn. The lines should vary in length from four to ten inches.

The emotional states should be kept vividly in mind by the subject while drawing the lines. He should in each case think of the situation for a short time before drawing the line, in order to 'work up' the affective state. Care should be taken that he does not know the amount nor direction of his errors until the experiment is finished. He should not even form an opinion of the direction in which his errors tend.

To avoid confusion it will be well for the experimenter to label

the successive pairs of lines as they are made. A convenient method of labeling is: A_1, unpleasant; A_2, pleasant. B_1, pleasant; B_2, unpleasant; C_1, unpleasant; C_2, pleasant, — etc.

Record: Present in the form of the table shown the length of the pleasant and unpleasant lines and the amount of their difference, in centimeters, for each trial. For each pair give also the per cent of the difference in terms of the length of the first line drawn in the pair.

PAIR	LENGTH OF PLEASANT LINE	LENGTH OF UNPLEASANT LINE	DIFFERENCE			
			PLEASANT LONGER		UNPLEASANT LONGER	
			AMT.	PER CENT	AMT.	PER CENT
A						
B						
C						
D						
E						
F						
G						
H						
I						
J						
AVERAGE:						

Questions: 1. What do your results indicate regarding the correlation of affective states and motor activity?

2. From a study of the percentile value of the differences between the first and second lines of the different pairs state whether the effect is the same on long and short lines.

3. Why was it necessary to alternate the order of the pleasant and unpleasant lines in the successive trials?

4. Describe from the literature three other methods for studying the physical accompaniments of affective or emotional states.

5. What practical significance have the results of your experiment?

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